JANUARY 1961

modern castings

Castings for Instant Power
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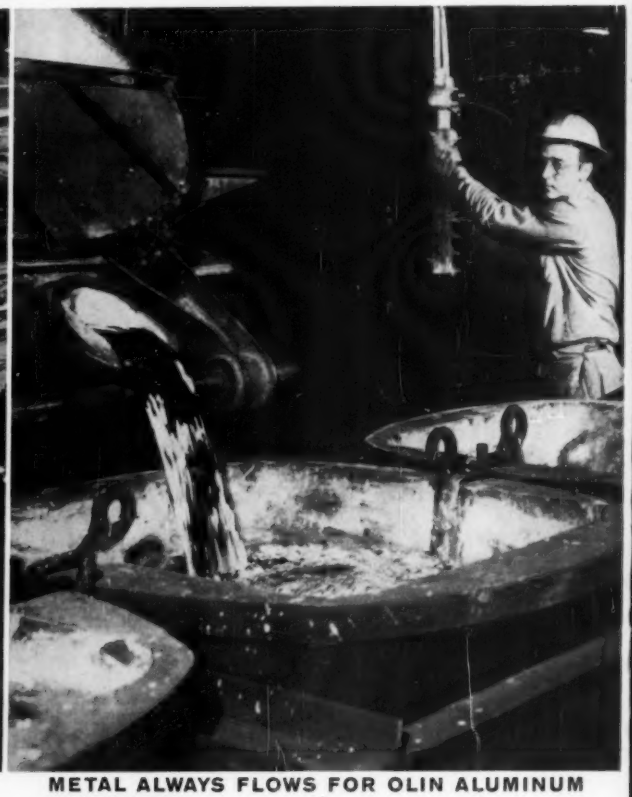
Aluminum Castings Head for Big Growth 48
How New Furfural Core Binders Cut Costs 31

Special answers to solve yo

DEPENDABILITY OF SUPPLY. From this huge new plant in Ohio comes a steady supply of primary casting alloys for the foundry industry—sold either directly or through Olin Aluminum Casting Alloy distributors throughout the nation.



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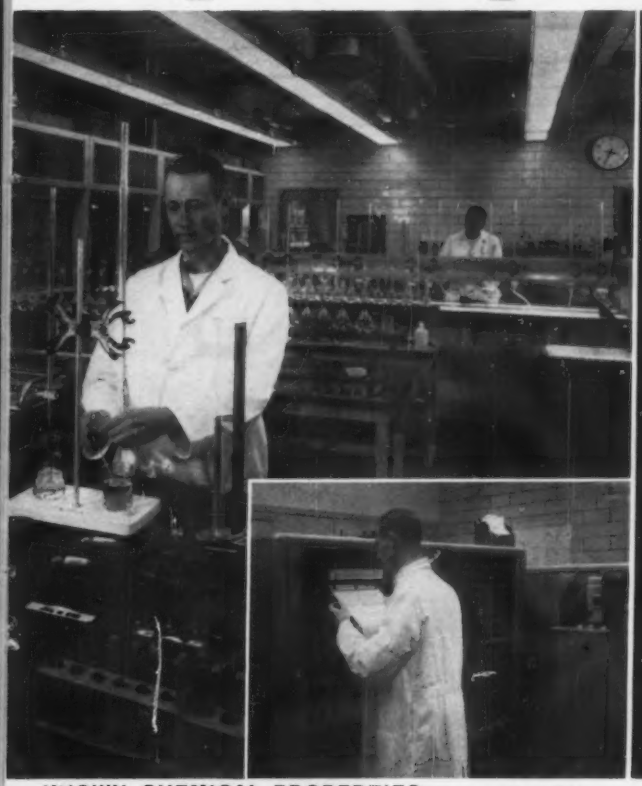

KNOWN CHEMICAL PROPERTIES. Every melt of Olin Aluminum undergoes exacting metallurgical and production controls. Skilled metallurgists use the latest and most efficient analytical and physical testing equipment.

MORE EFFICIENT FORMS. Olin Aluminum standard casting alloys come in 10, 25 and 50-lb. sizes. The 10 and 25 pounders feature smaller size to facilitate crucible charging, speed handling and melting. Deep notches and 4-section design are for easier breaking.

detailed Customer Requirement Records in the industry. And we don't sell castings ourselves–our policy is to help you to produce good castings. Call your local Olin Aluminum office or distributor listed below.

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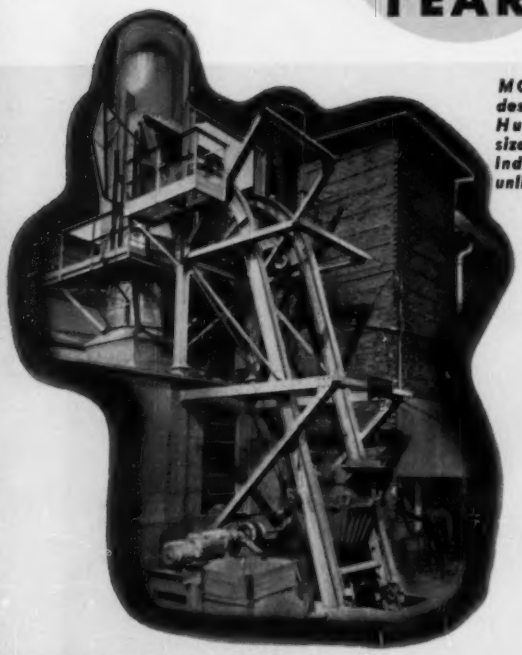

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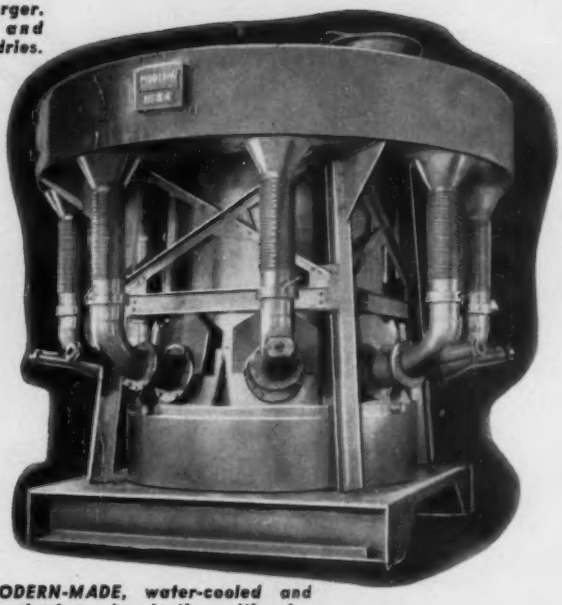
MODERN pioneered in designing the skip charger. Hundreds of types and sizes now serve foundries. Individual designs are unlimited.



MODERN-MADE, water-cooled and standard cupolas do the melting for most of the nation's foundries.

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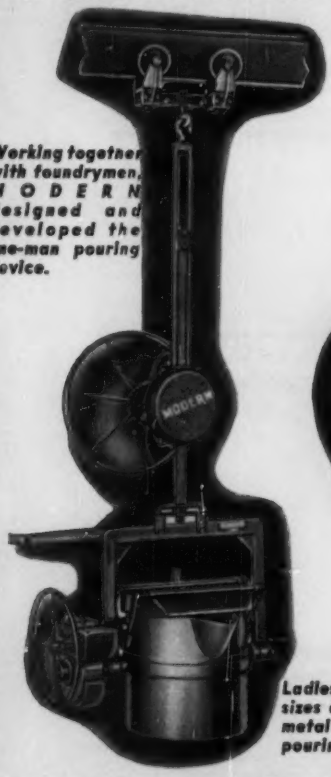
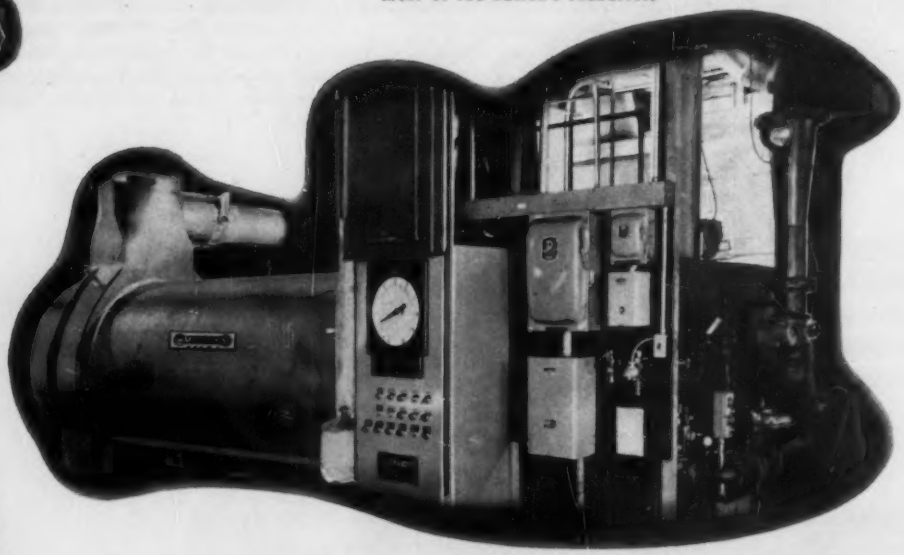


Ladles of all types and sizes are engineered to metal loads and to pouring conditions.



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January 1961 Vol. 39, No. 1

modern castings

metalcasting "technology-for-profit"

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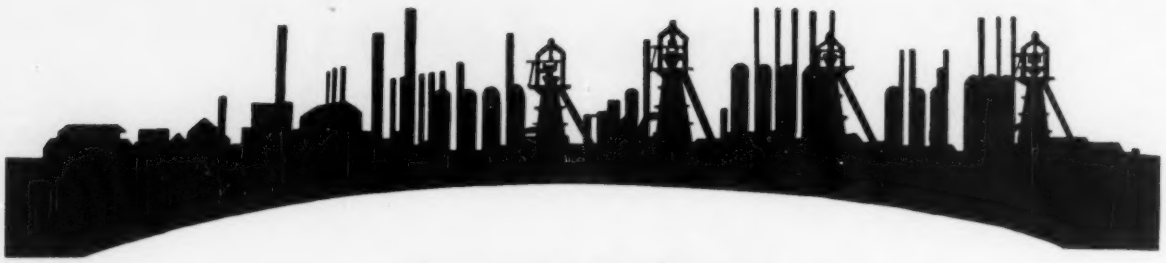

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Let's look at . . .

A UNIQUE EDITORIAL TEAM!

H. E. Green

EACH MONTH YOU have been reading in this "magazine image" column about the highlights of the issue—their significance and application to you.

This month, as the new year begins, it seems appropriate to tell you about those who produce this vital, *technology-for-profit* magazine.

As one who has been a professional business paper executive for many years, I can vouch for the fact that you have a unique, expert, and modern-day combination of editorial talent serving you.

Furthermore, this large group is organized to meet your daily needs. They're fast-moving and flexible, alert and enterprising. Out-moded concepts of staff organization and responsibilities have been cast aside to speed the flow of profit-making technology to you. The staff is tailored to meet *your* needs. Let's take a look!

First, there's a talented full-time core group of technical and journalistic experts: Editor Schaum, Managing Editor Glenn, News Editor Mott, and Castings Congress Editors McNeill and Hansen. They work with the Managing Director as a hard-hitting team. In my opinion, Editor Schaum is metalcasting's most outstanding technological communicator today. A key man in the industry's progress, he brings a wealth of metallurgical experience (both practical and research) to his post.

Second, come the columnists that serve you each month: Massari, Deitrich, Weber, Betterley. Each is a specialist in metalcasting. Each is nationally and internationally known. You get their suggestions and ideas monthly. We get the benefit of their daily contact with you and other metalcasters on an *even more frequent* basis.

Third, now serving you are four contributing editors, each working from an important geographical location of the industry. Vanick, Flemings, Wallace, and McMillan are all metallurgical experts who have outstanding reputations in metalcasting. In the nation's capital, Washington Editor Fingal brings you the talents of a long-time "pro."

Fourth, under News Editor Mott's aegis, more than 55 news correspondents report events to you from all over the world.

Fifth, every year a total of more than 200 expert authors in metalcasting bring you management and technical articles of substance. Most of these present to you *first* and *exclusively* the industry's technological breakthroughs.

All this adds up to the largest "editorial fare" in the industry (see our 12-page index of major articles and major features *only;* December, 1960 issue of MODERN CASTINGS). Each of these articles on news stories is designed to serve your *technology-for-profit* needs. They are presented to you in fast, easy-to-read fashion. The techniques are modern—journalistic enterprise at its best!

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Harold E Green

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Circle No. 131, Pages 141-142

Looking at Business with Modern Castings

NATIONAL SCENE

Predictions by John W. Craig, vice president of Westinghouse Electric Co. indicate major appliance sales will start climbing the last half of 1961 and will continue during 1962. Also, he believes sales for all of 1961 will be higher than those in 1960. Sales of major appliances (refrigerators, washers, ranges) follow the trend of new construction. Home building starts are expected for pick up early this year.

A check of the economic picture shows underlying strength, giving credance to an assumption that many companies are poised to capitalize strongly on marketing opportunities. This may presage a business upturn sooner than originally forecast by most economic experts. Caution is evident this month, reflecting business decisions made in late October, November, and early December. . . . . Inventories are at a level where replenishment will start modestly, but positively, this month. Seasonal activity will begin, as it always does, in such areas as farm implements, and appliances. New Product activity is picking up. A general upturn is in the making. Optimistic businessmen are saying that the first quarter of 1961 will match the nation's 1960 level. . . . . Currently, best estimates indicate that steel mill activity will be at 55% to 50% of capacity.

J. L. Block, board chairman of Inland Steel, doubts that the operating rate of steel is a proper measurement of the health of the steel industry, or of the overall economic climate of the country. He points to the huge growth in productivity capacity since World War II as being overlooked by commentators on the industry. He stresses that few industries use capacity as a yardstick, but judge—and are judged—by their output. Steel should be on the same basis. Steel production in 1960 was 3% better than the 1957-58-59 average, and this year it is expected to surpass both of the preceding two years.

NON-FERROUS SHIPMENTS

Almost 180 million pounds of non-ferrous castings were shipped in September, last year, according to latest government figures. This is 5% above August shipments. This total is comprised of: 61,357,000 pounds of copper and copper-base castings; 62,096,000 pounds of aluminum and aluminum-base castings; 52,514,000 pounds of zinc and zinc-base castings; plus 2,146,000 pounds of magnesium and magnesium-base castings. Of these, only copper shipments were down from the previous month. Aluminum was up 3,248,000 pounds; zinc, 7,413,000 pounds; and magnesium, 121,000 pounds.

FERROUS SHIPMENTS

Shipments of Gray iron castings in September (the latest month for which figures are available) totalled 900,497 short tons, or 42,994 short tons above August shipments. Last year's tonnage

was up more than 51,000 short tons in Sept. 1960 compared with Sept. 1959 shipments.

Malleable iron castings shipments were also up in September over the previous month by 4,263 short tons, for a total of 63,048 short tons. However, September figure was somewhat lower than that for the same month in 1959.

Also well above the August figure, shipments of steel castings during September were 104,298 short tons. August stood at 101,-709.

CASTINGS USE

More than 100,000 cast aluminum V-8 cylinder blocks and more than 200,000 cast aluminum cylinder heads for 1961 General Motors automobiles have been produced at the Central Foundry Division's Defiance, Ohio, plant. This is the first and only foundry in the U. S. to mass-produce V-8 blocks and valve-in-head cylinder heads in aluminum for automotive use. Production is greater than 1,000 blocks and 2,000 heads per day, by the semi-permanent mold process. They are used in the Buick Special V-8 engine and the optional engine in the Tempest.

Aluminum consumption during this year should continue at near record levels, reports Lawrence Litchfield, Jr., president of Aluminum Company of America. The demand is expected to be approximately 2,300,000 tons of the metal in all forms for the domestic and export markets. Consumption of aluminum during 1960 drew heavily on 1959 inventories.

According to Reynolds Metals Co. President R. S. Reynolds, Jr., primary production of aluminum this year will set a new industry record of about 2,021,000 tons.

Use of ductile iron castings is on the upswing, especially in the construction of compact cars, reports Arthur Avedision, vice president, The Taylor and Penn Co., Windsor, Conn. Weight reduction and the resultant economy contribute to the increased usage, as well as high strength, toughness, high fluidity and versatile castability.

EXPANSIONS

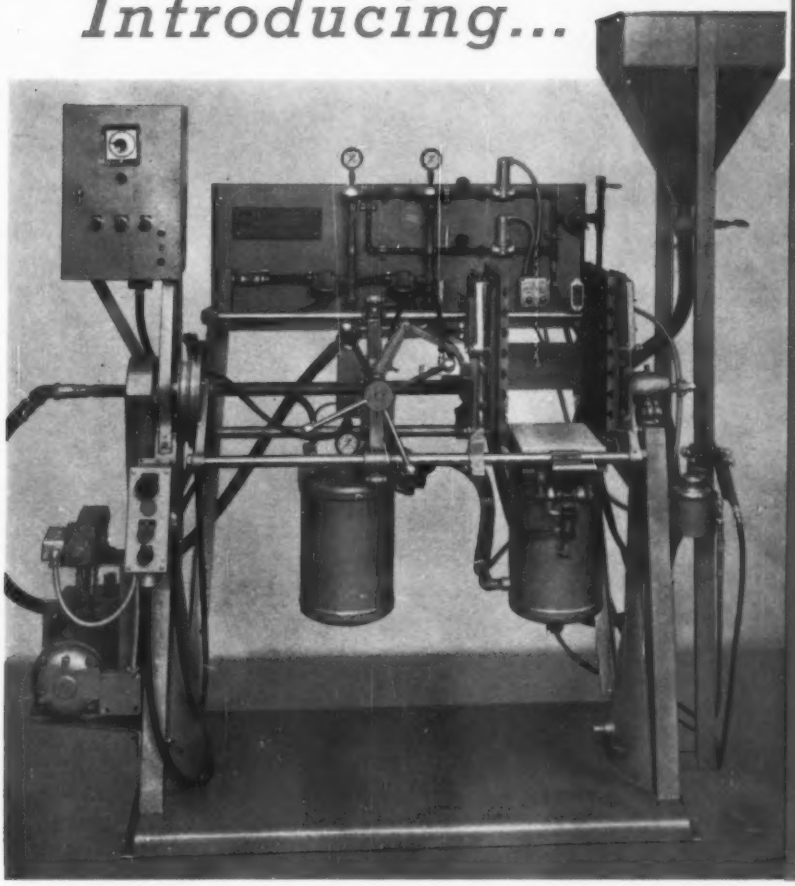
Alloy Steel Castings Co., Southampton, Pa. is erecting a separate building to house investment casting facilities.

Business is up for Central Foundry Co., New York City, if declaring dividends is any indication. The firm paid an additional 10¢ on top of its quarterly quarter per share to all stockholders on record as of Dec. 8.

International Harvester will cease operation of its Canton, Ill. gray iron foundry in May; switches the operation to five other Harvester foundries. This transfer follows company plans to close its farm implement plant at Rock Falls, Ill., moving to more efficient plants at Canton, Ill. and West Pullman works in Chicago. With the foundry out of the Canton plant, company will use facilities for production of disk harrows, blades and farm loaders.

Three plants of Bohn Aluminum & Brass Corp., Detroit, are being expanded. The Danville, Ill., Butler, Ind., and South Haven, Mich. plants get the increases. Heat transfer production facilities are being increased 20 per cent; enlarged permanent mold castings production facilities; and its a new engineering building at the three plants, respectively.

Introducing...



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Our new Model 200-A is designed for foundries requiring the ultimate in high production of shell cores at the lowest possible capital investment and operating expense. Simple operation (single push button) affords automatic, fast and economical production of a wide variety of shell cores with a minimum amount of attendance by the operator.

It uses natural, manufactured or bottled gas, thermostatically controlled, with the heat applied directly against the corebox. Individual temperature controls allow for accurate heating of all types of coreboxes with maximum efficiency. Simplicity of design and rugged cast construction reduces maintenance to a minimum. The automatic cycle is easily variable for quick change-over. It features automatic, continuous supply of sand.

Dependable Shell Core Machines, Inc. now produces five models: 100, 100-S, 200, 200-A and 400. Models 100-S and 400 can also be furnished fully automatic or with selected automatic features. "Special" models offer sand tank capacity up to 550 lbs. Each will produce cores adaptable to any method of foundry practice—ferrous and non-ferrous, conventional, shell or permanent molds. Each model is shipped completely equipped and assembled, ready to operate. No pits, foundations or plant alterations are necessary.

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Springfield Facing Corp. Willimansett, Mass.
Frederic B. Stevens, Inc. Detroit, Michigan
Frederic B. Stevens, Inc. (Vince Bruce, Inc.) Indianapolis, Indiana
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Your Beardsley & Piper representative will be happy to survey your core room needs and make his recommendations. He is well equipped through training and experience to aid in your selection. His recommendation, backed by B&P research and engineering, is your assurance of lasting satisfaction.

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Around the World with Modern Castings

UNITED STATES

At a special meeting in Washington, D. C., members of the Society of Business Magazine Editors were told about the phenomenal growth of 250 per cent in U. S. capital invested in Europe during the period 1950-59. Representatives of the six Common Market Countries explained how rising standards of living in their countries are booming demands for U. S. goods. Russia's future influence in the world trade markets is still an unknown factor. Thus far their activities have been aimed at disruption rather than profit.

U. S. industry must not forget that world trade is a two-way street. In the second quarter of 1960 our exports were valued at an annual rate of $19.6 billion—the second highest in history. Any trend toward erecting import barriers would probably bring about retaliatory measures that would seriously curb our exports.

Many do not realize that Japan ranks second only to Canada as the best customer of U. S. merchandise. In the next ten years machinery exports to Japan are expected to grow from $200 million to $575 million; coal to increase from $40 million to $160 million; and food from $175 million to $275 million. Too often our resentment to world trade is based strictly on how it hurts with no regard to how it helps our overall economy.

CANADA

That new monster—technological obsolescence—becomes increasingly evident in the foundry industry. One Canadian foundry applied the new technology of hexachlorethane mold wash for improved metal fluidity—as revealed in American Foundrymen's Society Castings Congress paper, p 86, August, 1959, MODERN CASTINGS. Then came another Castings Congress paper, p 91, September 1960, MODERN CASTINGS, which anticipated this practice with a mold wash technique involving amorphous carbon. Already this foundry is converting from its new wash to an even newer one. Another demonstration of applying technology for profit!

OVERSEAS

U. S. industry faces tougher competition in the years ahead from American owned producers abroad, Commerce Dept. warns. Direct U. S. business investments overseas at close of 1959 reached $29.7 billion, compared with $25.3 billion at end of 1957 and $11.8 billion in 1950. Over 2800 U. S. companies have direct investments in over 10,000 enterprises abroad. These produced goods worth $35 billion in 1959.

ITALY

In an exclusive MODERN CASTINGS interview Elio Calamari from Milan, Italy, revealed the tremendous strides being taken in Italy with low-frequency electric induction melting: "Some 30 per cent of the iron foundries in our country are equipped with low frequency induction melting and/or low frequency holding furnaces. These foundries are producing at least 50 per cent of Italy's iron output. Low frequency melting and holding furnaces are now in 80 per cent of our die cast-

ing shops. About 150 non-ferrous foundries have this type of melting equipment. Low frequency units range from 150 to 3000 pounds per hour capacity in non-ferrous; 200-900 pounds per hour for ferrous; and 1-25 tons for holding furnaces."

Mr. Calamari, a prominent builder of low frequency furnaces in Italy, is visiting the United States making final arrangements for Da-Prato Mfg. Co., Addison, Ill., to manufacture his unusual furnace designs. One model is the only low frequency furnace in the world capable of melting stainless steel.

CZECHOSLOVAKIA

A recent visitor to the United States was Dr. Petrzela, Polytechna Institute of Czechoslovakia, a world-wide authority on the CO_2 process for mold and core making. As guest of Cardox Div. of Chemetron Corp., he told a group of foundrymen at a reception in Chicago:

"CO_2 process has been used in Czechoslovakia since 1947 and today they lead the world in this technique. We use 2 per cent coal dust in our sand mix instead of sugar to improve surface finish on castings and shake-out properties. Mold and core surfaces are often hardened by spraying with sodium silicate solution containing an organic dye to insure uniform complete coverage. By covering mix with polyvinylchloride or polyethylene sheets the sand can be kept three days before using. Sodium hydroxide is added when clay content is sufficiently high to interfere with the normal reaction. In Czechoslovakia CO_2 sells for 15 cents per pound." (In U. S., price ranges from 4-10 cents).

A motion picture of practices in Czechoslovakia was shown. A copy of the film was left in this country and may be viewed through special arrangement with Cardox.

CANADA

Now you can determine gas content of aluminum melts quickly, and with accuracies previously unavailable to foundrymen. Watch MODERN CASTINGS for coming feature article by Neil and Burr, Aluminum Laboratories, Ltd., Ontario, describing new device which reveals hydrogen in molten aluminum alloys with a precision of $\pm$ 0.05 ml H_2 at N.T.P./100 g. By learning gas content in a matter of several minutes while metal is still in furnace, necessary steps can be taken to treat metal so only sound quality castings are made. This is a big technical step forward since heretofore fast procedures yielded inaccurate results and accurate tests required many hours of laboratory time.

RUSSIA

The Russians are making a mammoth effort to change the face of Soviet industry through automation. They plan to install 1300 automatic lines by 1965—aimed at basic industries such as steel, power, fuel etc. Business Week reports: "Literally thousands of scientists and engineers are being mobilized to transform theory into production line know-how. Special automation application institutes are being established. Four already exist; one at Kiev has 2000 engineers."

Automation controls for open hearths employ an analog computer which calculates heat input, absorption, and efficiency so furnace can be operated at optimum. A transistorized analog computer links 13 Soviet power stations in a single grid with computer providing distribution of power supply at minimum cost.

Both of these applications should benefit the foundry industry where trends are definitely toward electric melting and better efficiency.

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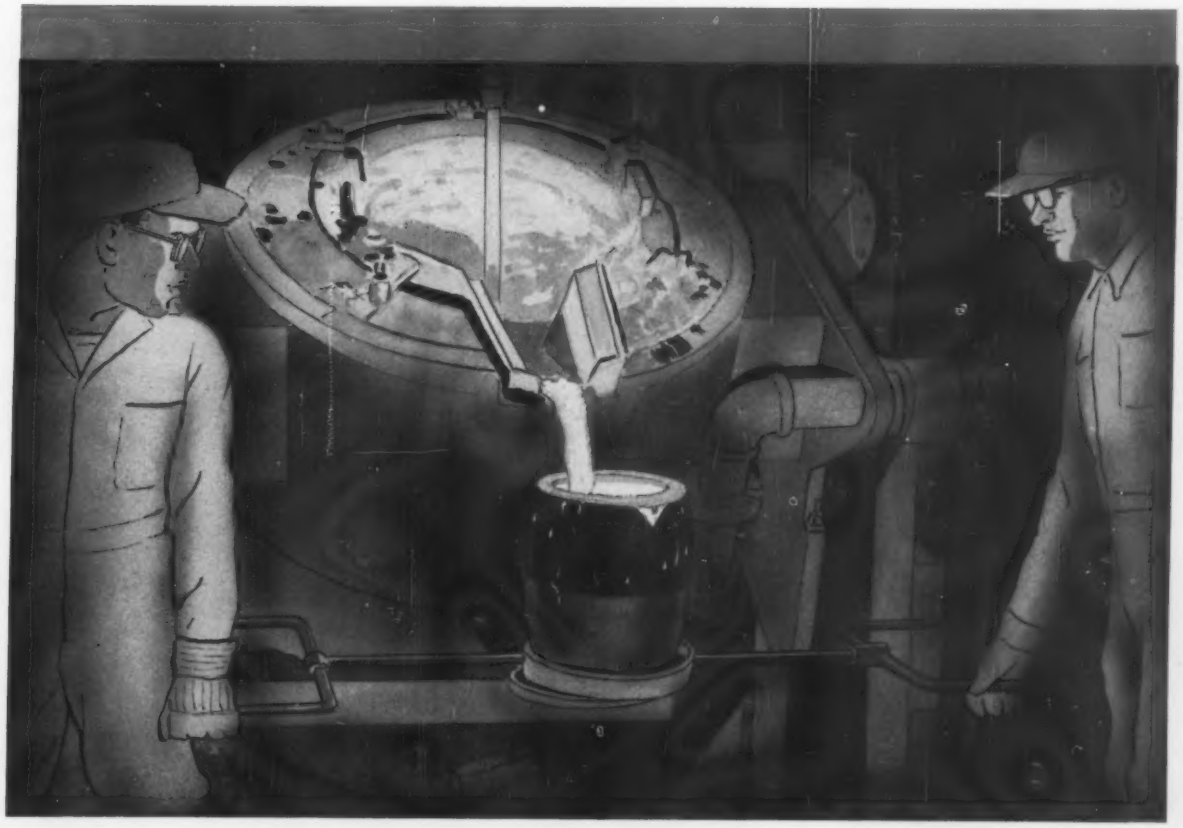

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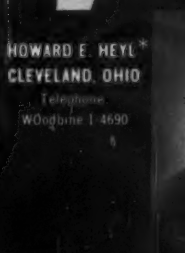

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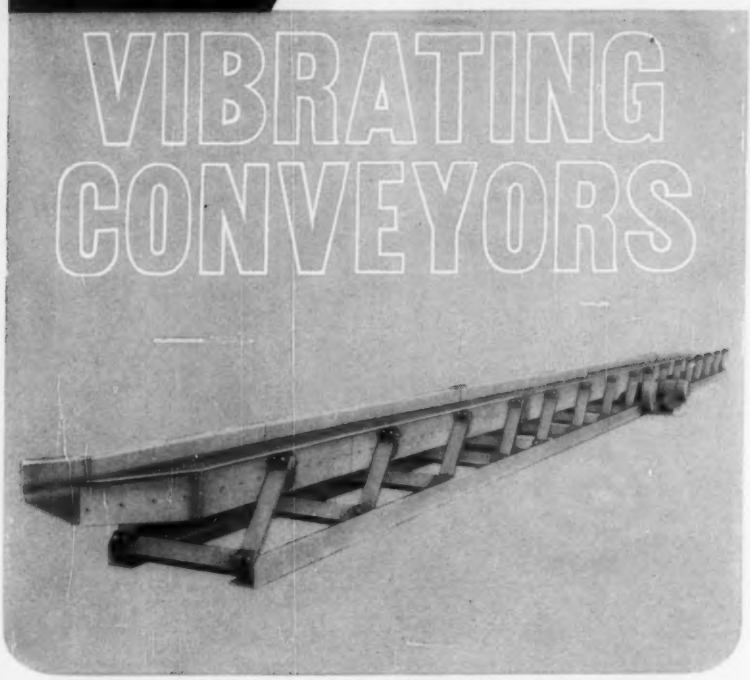

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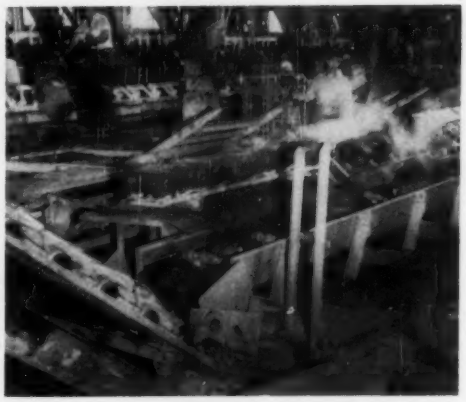

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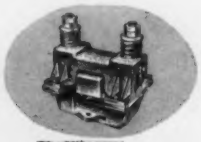

Bin Vibrators

Hopper Level Switches

Lapping Machines

Circle No. 135, Pages 141-142

Reader Opinions and Ideas . . .

THANK YOU FROM JAPAN

I am very grateful for the kind reception we received while visiting AFS Headquarters as a member of the Japanese Steel Castings Manufacturing Team. We visited 12 steel foundries and some other companies and societies in your country. We were deeply impressed by many kindnesses shown to us during our visit and also by the high productivity of your steel foundries.

KAZUO TAGUCHI
Komatsu Mfg. Co., Ltd.
Osaka-Fu, Japan

COPIES GOING OVERSEAS

Once again we are requesting 25 copies of recent issues of MODERN CASTINGS. Since the beginning of 1960 we have sent 33 commercial libraries to 26 countries.

These countries are Pakistan, India, Guinea, Ghana, Liberia, Sierra Leone, United Arab Republic, Uganda, New Zealand, Federation of Rhodesia and Nyasaland, Japan, Philippines, Peru, Italy, Morocco, Brazil, Ceylon, Australia, Colony of Singapore, Afghanistan, Iran, Malaya, Haiti, Kenya, France, and Tanganyika.

These libraries are used most effectively by our Trade Mission members and our embassies and consular posts in bringing to the attention of foreign businessmen the services and products available from U.S. firms.

The magazines too, are avidly read by the general public and are forceful demonstrations of the advancements in the industrial and economic life of our nation obtained through the free enterprise system.

E. PAUL HAWKS, Director
Trade Missions Program
Office of Trade Promotion
U.S. Department of Commerce
Washington, D. C.

MORE ON DEGASSING

In the November issue of MODERN CASTINGS I noted H. J. Weber's replies to several letters on the use of hexachloroethane to remove hydrogen from aluminum. I thought that you may be interested in the data I have accumulated on this material.

Hexachloroethane is a crystalline material which melts at 186.9-187.4 C., very slightly soluble in water but readily soluble in alcohol or ether. It

may be absorbed from the gastro-intestinal tract, through the lungs and through the skin.

According to one investigator, oral doses of 1-1.4 gm per Kg body-weight cause in dogs a moderate depression of the central nervous system. In rabbits the inhalation of its vapors caused a slow progressive depression of the central nervous system. The oral administration to dogs causes irritation of the gastro-intestinal tract and according to one investigator also some irritation of the kidneys.

Two other researchers determined the lethal dose with intravenous injection for dogs, killing the animals within 30 minutes as

100 mg/Kg for pentachloroethane
325mg/Kg for hexachloroethane
90 mg/Kg for chloroform

It appears, therefore, that hexachloroethane is the least toxic of these compounds. There are no references to the toxicity of this material for man. Normally the danger from the inhalation of its vapors would be quite remote because of the high boiling point, however, in this application, due to temperature of molten metal, this material will decompose to form corrosive gases.

Spraying in an ether solution creates an explosion hazard. Absorption through the skin may be considered a potential danger.

GEORGE E. TUBICH
Dist. Engr.
Div. of Occupational Health
Michigan Dept. of Health
Lansing, Mich.

HOT SAND PROPERTIES

The article "A New Concept for Hot Sand Properties" by Vingas and Zrimsek, in the November MODERN CASTINGS has undoubtedly received many comments throughout the foundry industry. Although their statements are true, I belive with a little more effort all of them can be explained.

Let us review some of sand fundamentals. Although core sands possess no hot strength, they have exceptionally high dry strengths. It is this high dry strength behind the mold metal interface that helps maintain mold stability. Let us consider a thin core within a heavy metal section. Metal penetration will result from the low hot strength unless additions of materials that increase the hot strength are used.

Expansion and hot strength go hand in hand. In the case of carbon molding, although there are exceptionally high hot strength values, the expansion is practically nil. In this instance no hot deformation is required. On

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Circle No. 136, Pages 141-142

the other hand, a sodium silicate sand with a high hot strength, unlike carbon has a high expansion. This is where the hot deformation of this material plays its roll.

Each test taken alone, will not give all the answers to our sand problems. We should always remember to correlate one or more tests together. The purpose of the elevated temperature tests is to give us a picture of what the binder or additive is doing in the mold. It is by working back from these tests that we can determine which remedy is needed to solve our sand problem.

A. G. JOHNSON,
Quality Control Supervisor
Canada Iron Foundries, Ltd.
Toronto, Canada

USING HOYT LECTURE

Many thanks for your recent letter enclosing reprints of the 1960 Charles Edgar Hoyt Memorial Lecture. These reprints are being distributed to many of our friends in the foundry industry and will be read with great interest.

J. D. BERRY
Birmid Industries Limited
Smethwick, Staffs, England

APPRENTICE RULES

Your letter concerning an error in the contest drawing was just in time, as we opened the local competition with this correction included.

We have been questioned regarding mounting the pattern on a match plate. Some feel the number of castings involved would warrant the use of this type of equipment, especially if a better parting could be made.

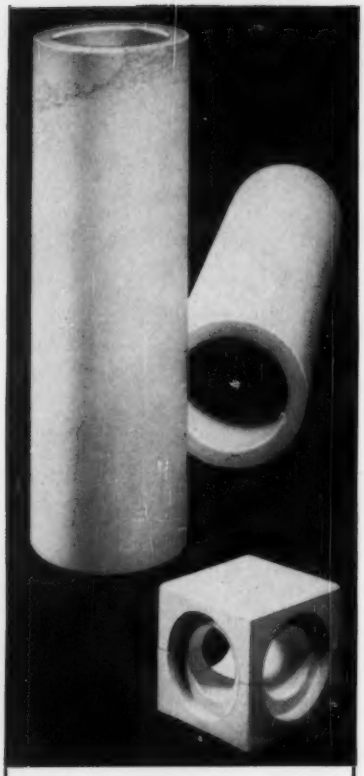
There were two entries in our group last year of this type but the judges did not find them eligible for national competition. The question has been raised in our committee as to whether your group would have marked down or up for this.

If it is possible for you to enlighten us regarding this question we would very much appreciate it.

C. C. MCDOWELL
Contest Chairman
Akron Pattern Makers
Akron, Ohio

I concur in your thinking that in this case the advantages of using this type of pattern equipment might be warranted because of parting and other advantages.

However, the Apprentice Contest



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Circle No. 137, Pages 141-142

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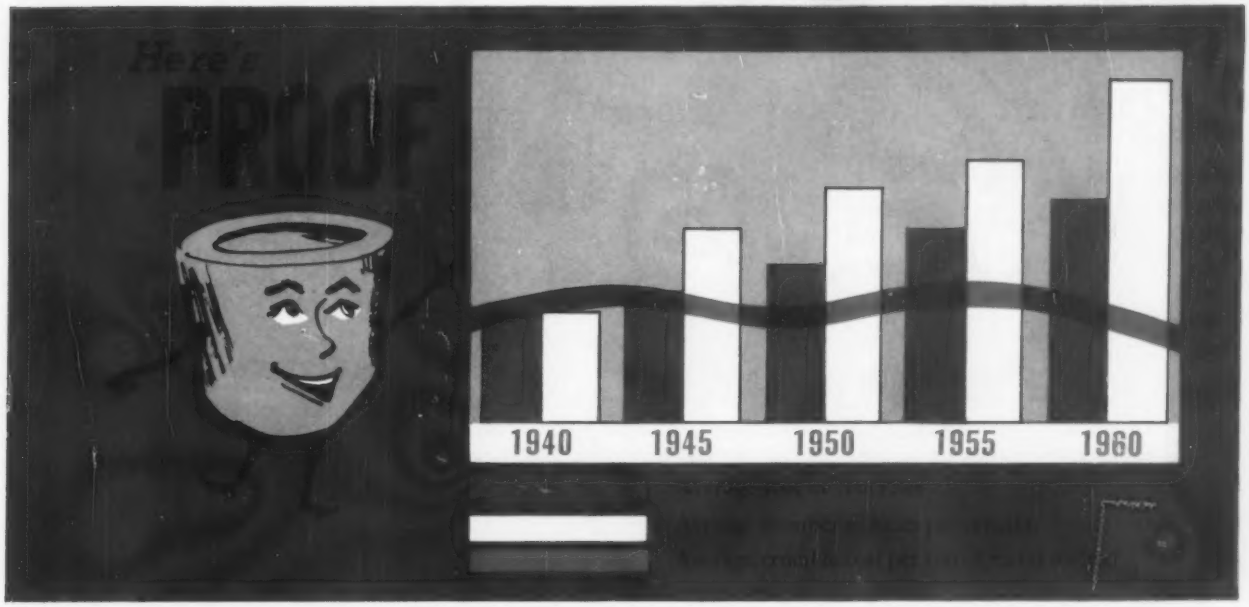

During the past twenty years the cost of everything has gone up—and crucibles are no exception. BUT—because of constant research on the part of crucible manufacturers, and resultant improvement, crucibles last much longer today than they did twenty years ago. They deliver *more heats*—and *bigger ones!*

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Can Chief and Princess see a difference?
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Circle No. 140, Pages 141-142

Committee has always felt that patterns for this competition should not be handled in this manner. One reason is the extra amount of time and materials involved in making this equipment. This also is the reason why we specify that no follow boards should be made.

It further makes it more difficult for the judging operation since there is not a comparable basis for judging the workmanship on the pattern when taking into account the amount of time spent.

When such match plate patterns have been submitted to the National Competition, the judges have neither marked up or down on these entries, but they have had to objectively grade these entries as to the time involved. We will therefore appreciate having all of your entries submitted without the use of a match plate or follow board. Ralph E. Betterley, AFS Education Director.

REQUEST FOR REPRINTS

I would appreciate receiving as soon as possible 200 reprints of my article "Ore to Molten Metal by Direct Reduction" appearing in the November issue of MODERN CASTINGS.

As it will take some time for the reprints, I would appreciate receiving as many tear sheets as possible.

ALBERT DE SY
Laboratory of Metallurgy
University of Ghent
Ghent, Belgium

ARTICLE FOR SCHOOL

We are interested in receiving reprints of the article "Wood Patternmaking for Foundrymen, Designers, and Patternmakers" in the December, 1958, issue of MODERN CASTINGS.

We are hoping to use this for classroom instruction and to send to various industrial arts teachers in Minneapolis.

What will be the charge for 100 reprints?

RUEBEN J. SCHAFER
Counselor-Coordinator
Minneapolis Public Schools
Minneapolis

Editor's Note: We have reprints of the article on hand. Glad to see that the Minneapolis schools are supporting the foundry and patternmaking courses in their educational program. Many articles appearing in MODERN CASTINGS *are suitable for use in schools. Educational material is also available through AFS as well as the Film "Cast Metals and You."*

Knight LETTER

FOURTH OF A SERIES

To: Foundry Management

Subject: Audit of Operations

Why should foundries consider a periodic audit of operations by Knight Engineers?

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. . . that methods and facilities permit highest productivity for men and machines.

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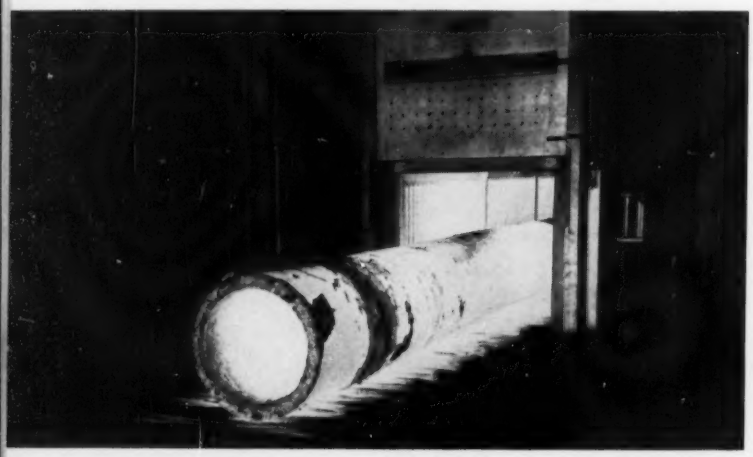
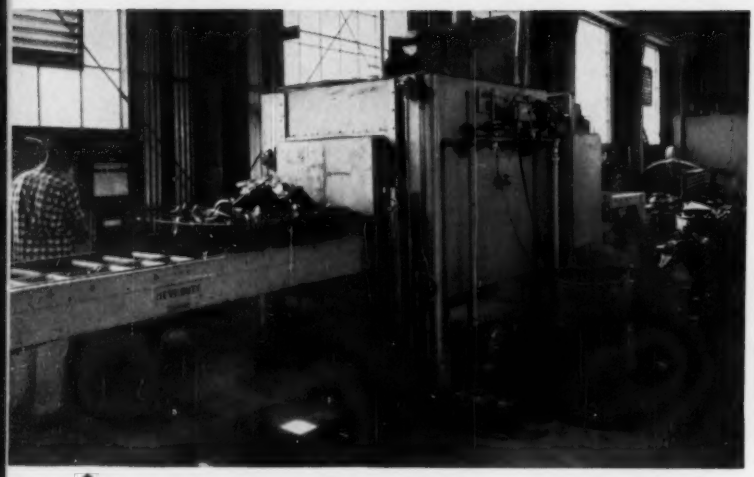


◀ Sandusky Foundry and Machine Company, Sandusky, Ohio, uses this Hevi-Duty car-bottom furnace to heat-treat castings up to 54 inches in diameter and 30 feet in length. Heating elements located in both ends, and in the car bottom, plus three fans, produce a degree of temperature uniformity generally expected only in smaller units. **For complete information, write for Bulletin 644R.**



▲ Pacific Steel Casting Company, San Francisco, California, is pleased with the operation of this Hevi-Duty Clean-Line Furnace. It heats, holds at the correct temperature for the prescribed period, transfers each load to the cooling chamber, and discharges baskets of castings automatically. A retractor on the unload table enables the Clean-Line Furnace to process four baskets without manual handling or supervision. Heat-treated castings come out ready for shipping without further attention. **For complete information on this, write for Bulletin D-100A.**

▲ Eaton Manufacturing Company's Valve Division really proves the ability of Hevi-Duty pit furnaces to maintain uniformity. They process dense 2,000-lb charges of valves — 10,000 to a load — all free from distortion, all uniformly hard . . . no rejects. An efficient fan and baffle system provides an even rate of heating throughout the dense load and contributes to over-all uniformity. **For complete information, send for Bulletin 646A.**

Freckles Always Got the Blame

by HERBERT J. WEBER

Remember the song?

"Freckles was his name,
He always used to get the blame
For every broken window pane
It was a shame!"

So, too, the foundry industry! Every time a municipality decides it has an air pollution problem, it immediately decides that the foundry stacks are the principal cause of all its woes and the officials start the air clean-up there.

The result of this mode of attack, of course, is that after control equipment has been installed on all foundries, there is little over-all benefit. The general atmospheric condition hasn't changed much.

The April 1960 report of the Los Angeles Air Pollution Control District "Technical Progress Report" states: "Since 1948, metallurgical melting operations in Los Angeles County have been subject to vigorous air pollution control measures. Both ferrous and non-ferrous metal melting operations have been subject to control. . . . ."

Anyone who has been to Los Angeles before 1948 and recently, knows that the air pollution problem there is, if anything, worse than before the "vigorous air pollution control measures."

The public should realize that it contributes in a major way to its own air pollution and that nonindustrial sources of air contaminants are the major contributor to a community's problem in many cases.

While the irate citizens inveigh against industry, are they willing to spend money for control of their own pollutants? For example, the cost of a catalytic combustion device installed on an automobile's exhaust will cost between $50 to $100 per year per car. Assuming a car life of three years, this mounts to an investment of five to ten per cent of the sales price of a $3000 car.

Yet industry is being forced to spend, in some jurisdictions, ten per cent of its capital worth for air pollution control; even though it is a lesser contributor to the pollution than the public itself.

Here are some sobering facts:

1. Each ton of fuel oil burned gives off 600 lb of oxides of sulphur, 27 lb of oxides of nitrogen, 5 lb of solids.

2. Each ton of fuel coal burned oil burned gives off 15 lb of sulphur 8 lb of oxides of nitrogen and 200 lb of solids.

3. Each ton of natural gas burned gives off 12 to 18 lb of nitrogen oxides.

4. Each ton of refuse burned gives off 2 to 8 lb of oxides of sulphur, 4 lb of oxides of nitrogen and 25 lb of solids.

5. Each 1000 gallons of diesel fuel oil burned gives off 15 lb. of sulphur oxides, 75 lb of oxides of nitrogen, 100 lb of solids and 30 lb of aldehydes.

6. Each 1000 gallons of gasoline burned in automobile engines disperse through exhausts 17 lb of sulphur oxides, 25 to 75 lb of oxides of nitrogen, 18 lb of aldehydes, 3200 lb of carbon monoxide and 200 to 400 lb of hydrocarbons.

In 1949 there were 79 cupolas operating in Los Angeles County; in 1953, 52; and in 1959, 40.

This could mean that foundries are merging; moving out; going to other kinds of melting equipment; or going out of business because of poor management or excessive cost of air pollution controls.

I don't know the reason for that decrease in the number of cupolas.

There is no intention to imply that industry should do nothing about control of its emissions. It seems to me, however, that an effective program necessarily must include control of emissions caused by the people themselves.

"And when the cat had kittens out in the hay,
One was black and seven were gray,
Everybody said 'Freckles,'
He always got the blame."

Circle No. 143, Pages 141-142 ⟶

how we help you make the plunge

Much of the ductile iron now being produced uses the plunging technique. Increased magnesium recovery, improved control and lower cost result. Flame and smoke are virtually eliminated and cleaner metal is produced.

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#2 Sil-Mag M—16-20% Mg, 60-65% Si, 1.0% Min. Rare Earths.

Also available without Rare Earth Metals.

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If you are not taking advantage of the plunging technique, we would be happy to have our qualified foundry service personnel discuss this method with you. Detailed information on ductile iron and alloying techniques is presented in our brochures, **Sil-Mag Alloys for Ductile Iron** and **Plunging Sil-Mag Alloys**. A copy is yours for the asking.

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Ohio Ferro-Alloys Corporation
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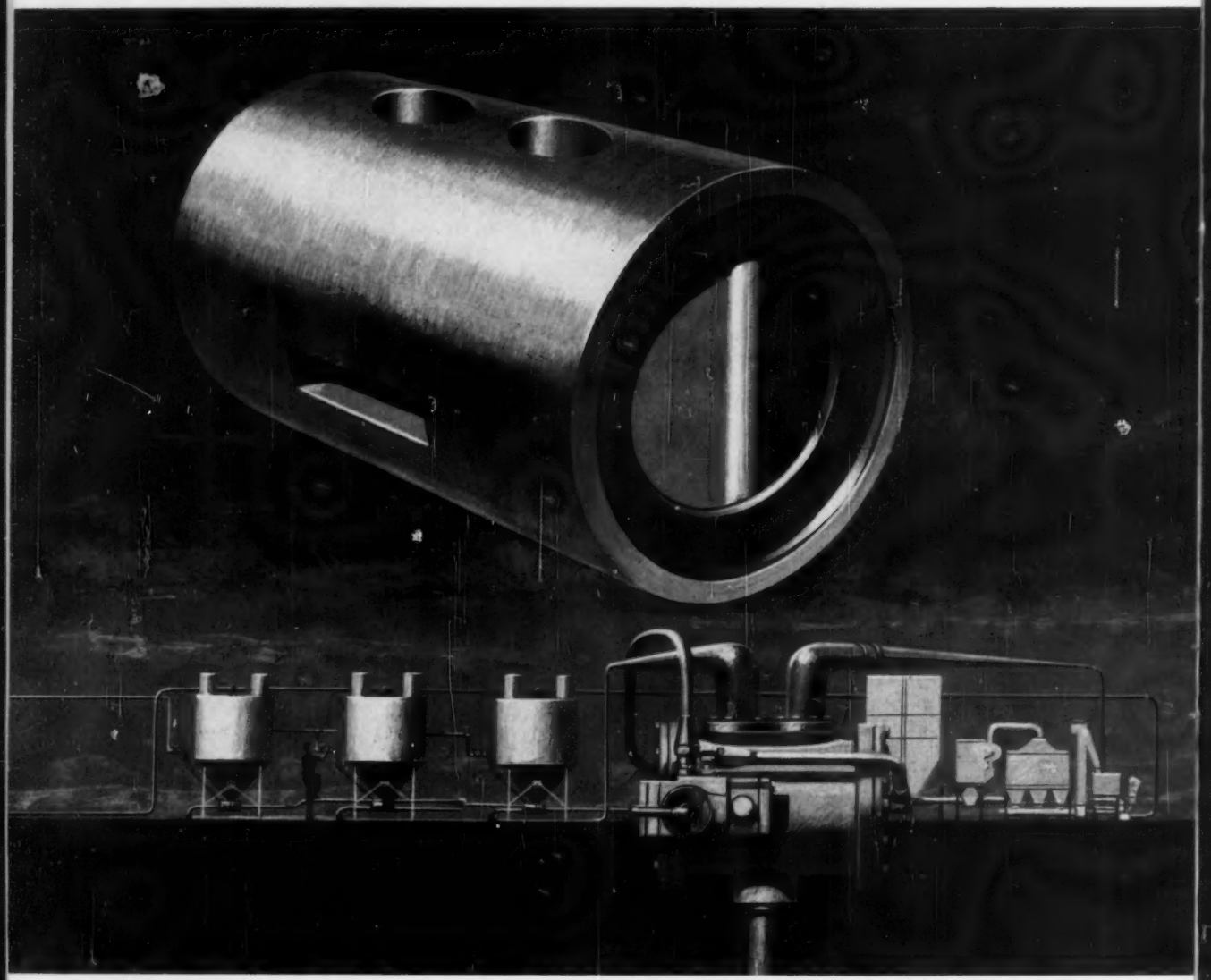

CAST IRON PISTON OUTPERFORMS WELDMENT, DROPS COST 55%

The piston in a diverter valve was being made from welded steel tubing and plate at a cost of $61.07—$58.64 of it for machining. Occasionally the welds would crack, causing the piston to stick.

Redesigning the part for a gray iron casting eliminated several machining operations and a stress relieving operation after welding. New cost per piece was just $27.72. Both the rigidity and the appearance of the piston were improved. A more dependable product was realized for less than half the former cost. It's another impressive example of the outstanding performance and economy offered by modern iron castings.

For the production of structurally sound iron castings, Hanna Furnace provides foundries with all regular grades of pig iron . . . foundry, malleable, Bessemer, intermediate low phosphorous, as well as HANNA-TITE® and Hanna Silvery.

Facts from files of Gray Iron Founders' Society

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How the Foundry Industry Serves America — #22 of a Series
CAST IRON PISTON OUTPERFORMS WELDMENT, DROPS COST 55%
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If you would like to have reprints of this ad to mail to your customers and prospects, let us know. Reprints will have no Hanna product message or signature, but will be imprinted with your firm name and address. Absolutely no obligation. To order your reprints, fill in and mail the coupon below.

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Circle No. 144, Pages 141-142

"The Hole in the Roof"

Time For Repairing Parallels
Industry's best Time To Train

by RALPH BETTERLEY

Since the October issue, this writer has been expounding many of the ten points proposed in the original article, "Mileage From Your Training Dollar." (See September issue of MODERN CASTINGS, page 25.) Now, I shall elaborate point No. 4: "Select the Right Time for Courses."

In clear weather, the "hole in the roof" is no problem. The *need* for repair doesn't exist *at that time*. But when it's raining cats and dogs and enough water is coming in to operate a water-cooled cupola, *repair* is out of the question. Unfortunately, this "hole-in-the-roof" philosophy is more prevalent than you might realize. Perhaps slightly exaggerated, but aren't some managements guilty of this type of reasoning where training, preventive maintenance and a host of similar foundry problems are concerned?

There is some indication that foundry business is "slow"—perhaps it is. However, I've been pleased to learn recently that a number of foundries are using this time advantageously to train personnel, effect major changes and accomplish needed preventive maintenance.

Figuratively speaking again, this is fixing the "hole in the roof" *when the sun is shining*—the best time, regardless of *need*. Making good use of a slow time improves a foundry's competitive position when business is "booming" again.

Forward-thinking metalcasting managements, with production down, are utilizing some of this time for in-plant training programs, technical seminars and out-of-plant intensive foundry courses. This training can help provide the preparation so vitally needed in our rapidly changing technology. "Slow" times give opportunities for research, experimentation and new approaches to the solution of the industry's problems.

Answers found *now* can pay off when foundry personnel are "busier than one-legged Indians at a stomp dance" meeting production schedules. Sometimes it is valuable also to *have the time* to try out procedures which prove to be impractical for a specific plant's operations. Only through "chalking off" such steps and trying new ones can progress be achieved.

Since our original column dealt with the utilization of outside training courses, we should consider these programs when business is slack. Many foundries have found short work schedules the best time to send key-personnel to these courses. Responsible personnel can be spared and it provides excellent opportunities for technical development and personnel up-grading.

The AFS-Training and Research Institute's intensive courses have numerous registrants enrolled as a result of this practical thinking. It is just as difficult to spare supervisory personnel during rush business as it is to fix the "hole in the roof" when it's pouring—remember?

Another important point is that these programs are organized and immediately available for foundrymen needing this training. Inquiries to the writer point out, in spite of good intentions, there is a lack of planning and preparation on the part of plants to have readily available organized courses which can be implemented quickly. In such cases, the courses of the Training and Research Institute can be of utmost industry use.

To maintain technical excellence in a highly competitive market, foundries must continually seek opportune times for training. Timing is important, both from the standpoint of courses and personnel.

Ideally, a man should receive intensive training when he needs, and knows that he needs, a deeper insight into a specific area of technology being explored or used by his company. With this as a basis also consider low-production times for optimum training effort as time to fix the "hole in the roof."

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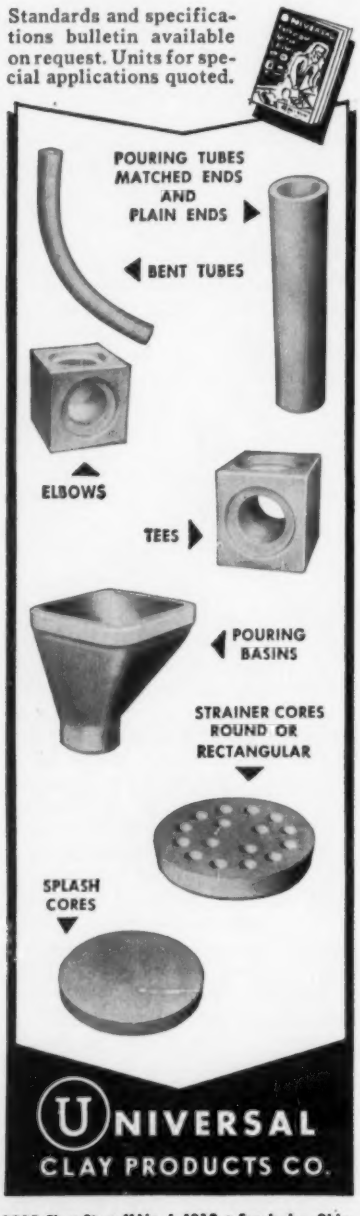

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Circle No. 145, Pages 141-142

Forgotten! The Third-Shift-Foreman

by H. F. DIETRICH

If the foundry ever developed a forgotten man, it is the Third-Shift-Foreman. Shunned by management, ignored by maintenance engineers, and belittled by foremen on other shifts, the Third-Shift-Foreman lives in a world by himself. To survive, he must be a diplomat, an introvert, and a mechanical genius.

After a time, this life of "solitary confinement" develops a canny, calculating, egocentricity in some third-shift-foremen that keeps them alive. I once followed such a character, named Kelly, on the morning shift. If there were any angles designed to plague morning-shift-foremen, Kelly knew them. For those situations which had no precedent, Kelly would invent one.

Kelly came to the conclusion that the only contact he had with management was through the production records. He reasoned that if his record were better than that of the other foremen on the unit he would make an impression. To this end he did what he could to improve his record. It became an obsession.

After Kelly's crew had reached the point of highest efficiency, there was only one way to gain further improvement . . . lower the efficiency of the other crews. This is where things began to get sticky. He insisted that patterns must be ready for him to run at the starting whistle. He worked his crew until the last whistle. Then he left his patterns on the machines to be changed by the crew which followed. This effectively lowered its working time. Defective molds, that should have been shaken out, were left on the floor to be cleaned up by the next crew. Worn conveyor wheels would miraculously run for Kelly until the last whistle blew. Then they would fall off.

Kelly eventually gained the advantage. Management pointed to his record, on paper, and held it up as an example to the other unit crews. The work stoppages he caused by his tactics didn't show up on paper. There was no place on the production report sheet to explain delayed breakdown, house-cleaning, or delayed starting time. Kelly was a fair-haired boy until the other crews began to devise ways to retaliate. With each crew following Kelly's example, the total efficiency of the unit was impaired, and it took a major shake-up to get it back on an efficient operating basis.

The practice of productive competition is unfair to the Third-Shift-Foreman. During daylight hours, generally an absentee can be replaced at once. But where can you find a man to go to work at 11:00 p.m.? For this reason the foreman must be a diplomat. If he looses a man on his shift, he must finish shorthanded. Who can be diplomatic at 4:00 a.m.? Only a Third-Shift-Foreman.

During the daytime, the shop is filled with engineers and experts of all kinds. If a problem arises, it can be solved by the combined efforts of specialists. The Third-Shift-Foreman has no such expert help. And getting one out of bed at 3:00 a.m. is a dangerous practice, to be tried only in desperation. The Third-Shift-Foreman, therefore, must be an introvert; an island unto himself. He can look to no one for help.

For some reason unknown to modern man, machinery reaches its fatigue limit between 3:00 and 5:00 a.m., hours when all mechanics are getting their best sleep—at home, or on the job. From my own experience as Third-Shift-Foreman, believe me, mechanics are hard to find. It is easier to get a set of tools and do your own repairs. The foreman must be a mechanical genius and nurse temperamental machines through the early morning hours.

Into this key position on a three-shift unit, we usually place the most inexperienced men and expect them to out-produce the day crew. Why? —Any comments? Let's hear from you!

METALGRAMS

UNION CARBIDE METALS

. . . news of "Electromet" ferroalloys and metals

JANUARY, 1961

A LOW-COST ALLOY FOR DUCTILE IRON -- One of the fastest growing cast metals in tons produced is ductile iron. The material combines economy and good casting properties with good strength, elastic modulus, moderate toughness and good wear resistance and corrosion resistance. "EM" magnesium-ferrosilicon is widely used as the magnesium addition that produces the ductile iron structure. This economical alloy can be used in the open-ladle or plunging methods of treatment. Your Union Carbide Metals representative will be glad to help you develop efficient production techniques. Ask for F-20,069 and F-20,120.

* * *

LOW COSTS WITH CHARGE CHROME -- In recent years, the use of charge chrome in stainless steel melting has increased markedly. The reason: they are the lowest-cost ferrochromes available. Union Carbide Metals offers three alloys with different chromium, carbon, and silicon contents to meet individual practices. UCM's studies using a high-speed computer have helped steelmakers select the charge chrome that will give lowest costs. Look to Union Carbide Metals for help on the most economical use of charge chrome alloys. For more information, write for the article, "Predicting Minimum Materials Cost for Stainless Steel," in the Spring 1959 issue of UNION CARBIDE METALS REVIEW.

* * *

WHY BUY AMERICAN? -- Ferroalloy imports doubled between 1955 and 1959. Steel, iron, and nonferrous imports are up sharply too! Foreign producers have low wage rates which enable them to compete on a price basis in the U. S. However, they cannot compete with U. S. producers on three counts: (1) valuable metallurgical assistance at a user's plant, (2) consistent quality in all materials, and (3) products delivered quickly when the customer wants them. For further information, write for the article, "Why Buy American?," in the Fall 1960 issue of UNION CARBIDE METALS REVIEW.

* * *

MANGANESE IN ALUMINUM -- Manganese is used in aluminum casting alloys to neutralize the embrittling effect of iron and to increase strength. Other effects of manganese include better high-temperature properties, reduced hot shortness, improved machinability, and less chance of soldering in die casting. UCM offers low-iron ferromanganese and "Elmang" electrolytic manganese for manganese additions to aluminum. For more information on wrought and cast applications, write for the article, "Manganese Puts Muscle in Aluminum," in the Winter 1961 issue of UNION CARBIDE METALS REVIEW.

* * *

BETTER MACHINABILITY -- Polls of gray iron castings users have indicated that they rate good machinability as "extremely important." Foundrymen are improving the machinability of their castings by inoculating iron in the ladle with "SMZ" alloy. This strong graphitizing inoculant eliminates chilled corners and edges that cause excessive tool wear and breakage in the machine shop. As much as 25 per cent faster machining rates have been reported. Only 2 to 4 lb. of "SMZ" alloy per ton generally eliminate chill. Further facts can be obtained by writing for a 16-page booklet, F-4604C.

* * *

UNION CARBIDE METALS COMPANY, Division of Union Carbide Corporation, 270 Park Ave., New York 17, N. Y. In Canada: Union Carbide Canada Ltd., Toronto.

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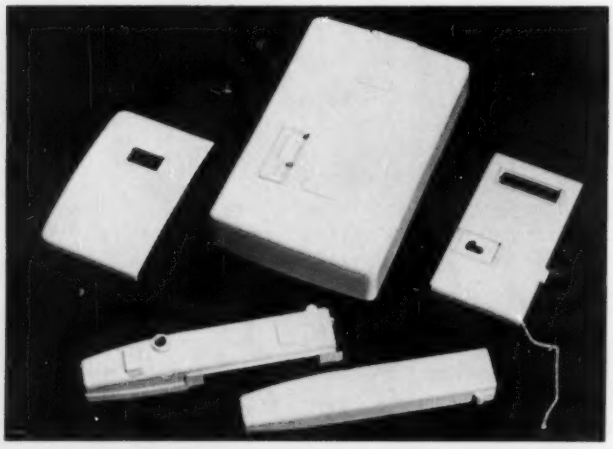
Here's How . . .

the latest foundry developments may help you perform a better job.

. . . malleable iron castings support 4-acre reinforced concrete umbrella roof at Pan American World Airways terminal at New York International Airport. The giant canopy is supported by 32 sets of castings used as fulcrums atop reinforced concrete piers. The roof cantilevers 114 ft out into space. Each assembly consists of four castings weighing a total of 2660 lb. Castings were made by Lehigh Foundries, Easton, Pa.

. . . naval designers solved the high stress and corrosive sea water exposure problems involved in torpedo tube service. Newly developed hardenable cast stainless alloy was selected for the breech door of the new "Thresher" class nuclear attack submarines. Casting is 26 in. in diameter and weighs 250 lb. *Official photo, U.S. Navy.*



. . . manufacturer of combination camera-projector cut weight of housing by 31 per cent. Longines-Wittnauer Watch Co. uses five magnesium die castings for structural strength while keeping weight of unit to four pounds—found to be the ideal weight by designers.

. . . Ni-Hard castings are used by Nordberg Mfg. Co., Milwaukee, to meet rugged service requirements of the cement industry. Shown is grinding mill feed spout which has cast-in spill return. Parts may be cast for normal methods of fastening including bolting, zincing, and keying.

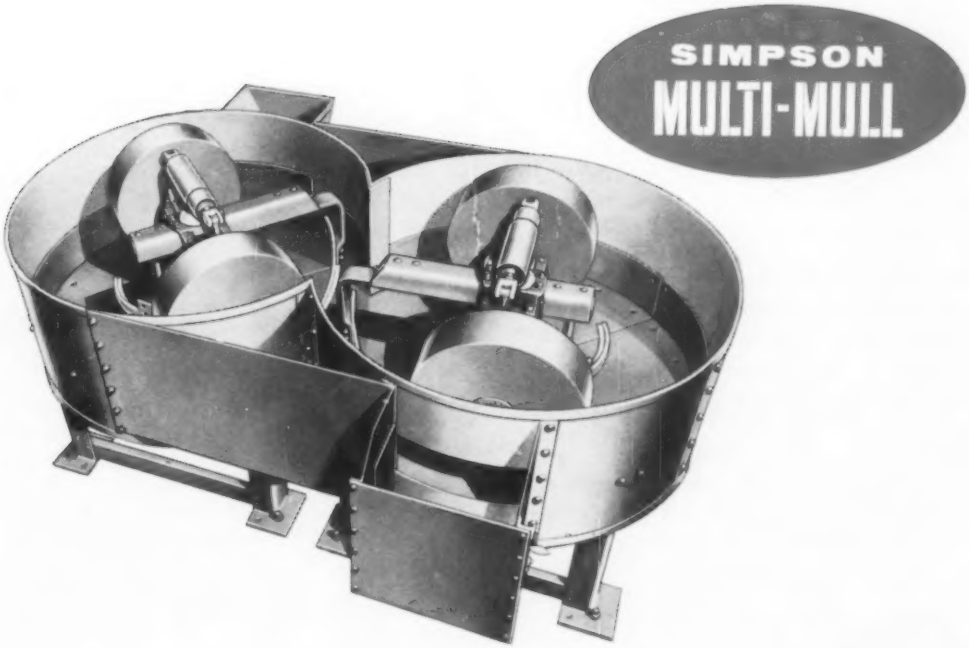
I mull sand the new way...

Continuously:

I do it carefully and thoroughly

and, I'm big enough or small enough

...to meet *any* molding requirement.



Foundrymen who are aggressively waging the battle of cost vs. quality are winning—with Simpson Multi-Mull.

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NATIONAL ENGINEERING COMPANY

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Circle No. 147, Pages 141-142

EVERY little pig goes to Market

No little pig stays home—for some other purpose. The entire production of Interlake's famous Meltrite pig iron is for sale.

This means you can always count on Meltrite. It is in dependable supply at all times ...a key reason why foundries use more Meltrite than any other merchant pig iron.

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Circle No. 148, Pages 141-142

New Furfural Binders Reduce Core Cost

Speed production at International Harvester's Milwaukee Works with better dimensional control and improved product reliability.

Eliminate ovens, driers, and wires while easing scheduling problems and reducing lead time required.

Simplify mixing operations—only sand, catalyst, and binder are required. New process finds increasing use in foundries.

FOUNDRYMEN EVERYWHERE are speculating as to where the new process which they call "furfural" will fit into the coremaking picture. International Harvester has not wasted any time in discovering for itself how furfural can reduce core and casting costs in its foundries. Material cost of the new "F" process is about one quarter of what they are paying for phenolic resin coated sand to produce shell cores. Add to this the increased productivity of three to four "F" cores made in the same time intervals as one shell core, and you can appreciate the excitement that furfural is stimulating in the metalcasting industry.

When these new core binders were introduced to the foundry industry early this year, many were quick to recognize the potentials, and several Harvester foundries along with the company's Manufacturing Research facility began to work with the material almost simultaneously. Harvester's Milwaukee Works foundry was planning new equipment for model changes on certain cylinder heads. It was soon apparent that through the use of this material they could produce a number of castings at a lower cost and with better dimensional control than was originally anticipated.

First let's clarify the chemistry of this new binder. It consists of a urea-formaldehyde resin modified with furfuryl alcohol, which is produced by a patented process. This type of resin was first developed for use as a glue in the plywood industry and has been in use for about 10 years. The binder is mixed with sand and a mild acid which acts as a hardening catalyst. The presence of furfuryl alcohol in the resin makes possible progressive curing of the resin due to a mild exothermic reaction between the acid catalyst and the alcohol in the presence of heat. Some of the catalysts being used are phosphoric acid, ferric chloride, and ammonium phosphate.

The acid-binder reaction takes place slowly at room temperature, and the mix has a bench life of 4 or 5 hours. When the mix is blown into a hot corebox, the thermosetting exothermic chemical reaction is initiated which binds the sand grains into a hard core. A thoroughly cured core will resist the action of water in the same way a shell core does.

Any conventional sand mixing equipment is suitable for mixing the "F" process ingredients. Since the uncured resin is water-soluble, the mixer is easily cleaned up for other use. Harvester's Milwaukee Works uses a washed and dried, four-screen lake sand with a 45 grain fineness number. Six hundred pounds of sand and 0.4 per cent of catalyst solution are mulled together for 30 seconds. Then 2 per cent of the furfural binder is added and mulling is continued for an additional 3-1/2 minutes.

Discharged sand is transported by monorail to a hopper which gravity feeds the core blowers located on the floor below. Sand, catalyst, and binder are the only three ingredients involved. Since oil-sand core mixes often consist of

six or more ingredients, a significant savings can be realized from the reduction in the amount of material that must be handled, stored, measured, and inventoried.

Blowing "F" cores requires a different approach than that used for shell cores. Shell sands are dry and flow with ease. The "F" process mix is sticky and sluggish. This makes it difficult to introduce into a core box by the popular rollover-blow technique used for shell except for the simplest of shapes. For the same reason, furfural bonded sand won't drain out of a skin hardened core to produce a hollow core as in the shell process.

Due to the differential in material cost, small solid "F" cores will have the advantage over comparative hollow shell cores. On the larger cores where size and weight become a factor, the furfural cores can be made in halves. By blowing each half through a contoured mandrel, a hollow core can be produced with controlled wall thickness and interior ribbing for strength where necessary.

Blowing The Core

The blowability of the "F" process mix closely resembles that of an oil sand core mix. Relatively high air pressure, in the range of 50-100 psi, is needed to produce a sound, dense core. Venting techniques are also more similar to blowing conventional mixes than shell. With the higher blow pressures being used, a larger volume of air must pass through the corebox, and more venting area has to be provided. A clearance of 0.015" around the ejector pins picks up some of this area. More is provided through 0.005" slots on the parting lines, and the rest is made up with regular slotted vents.

The "F" cores slip out of the corebox with relative ease. After the box is well broken in, only an occasional application of parting agent is required. The same kind of parting agents used on shell coreboxes work well on the furfural boxes.

Hot coreboxes for the "F" process are generally made from a good grade of dense gray iron the same as shell coreboxes. Some of Milwaukee Works' boxes are fully machined. Others are cast-to-size in ceramic molds. The method used to make a specific corebox is determined by the complexity of the core and the degree of precision required.

All of the furfural cores are blown through slots along the parting line. Thickness of the slots varies from 1/8 to 3/8 inch. Since the boxes are gas heated, the back of each box is contoured to approximately a uniform wall thickness.

Basically, there is little difference between a well-designed shell box and a furfural box . . . . with the exception of additional venting as mentioned before. Harvester's Milwaukee Works foundry has switched from shell to furfural on a number of jobs with little fuss.

Blowing Equipment

A new breed of coreblowers is being developed to handle the "F" process sands. Some shell coreblowers are being modified for this purpose, and some oil-sand blowers are also being changed. Equipment manufacturers are beginning to produce blowers specifically built for the material. These incorporate the desirable features of each such as:

1. High pressure, conventional type blowheads capable of moving the sand.
2. Vibratory feed machanisms to supply sand to the blowhead.
3. High pressure clamping of box halves.
4. Thermostatically controlled heat for each half of the corebox.
5. Automatic timing on blow and cure cycles.
6. Core ejection pins.
7. Water cooled blowplates.
8. Quick-change mountings for coreboxes and blowplates.

The temperature of the box is a variable worked out for each job. On the job the box was running at 500 F. with a cure time of 15 seconds. Usually the optimum temperature and cure time for a new box can be worked out while cores are being blown to check out the venting system. Curing too long or at too high a temperature burns the surface of the core and it becomes soft and friable. Cure times generally run from 12 to 30 seconds.

The core does not have to be completely cured in the box. Once the hardening reaction has penetrated deep enough to give the core sufficient strength for handling, it can be ejected and removed. Chemical hardening all the way through the cross-section is completed within a few minutes after the core is taken from the corebox. Cores with a heavy cross-section have to be cured longer to ensure that the reaction is not killed by the heat being absorbed too rapidly by a large mass of sand. Such cores are usually blown on a mandrel or given another shot of heat for a short time in an oven to complete the job.

Using The Cores

The "F" cores are doing a good job in the foundry. Their collapsibility is better than oil bonded cores so shakeout is easier and hot-tear possibilities are reduced. Casting finish obtained from the furfural cores is not as smooth as from shell cores, but is comparable to oil sand. Most of the cores at Milwaukee Works are dipped in a wash, the same as if they were oil sand cores. They produce an equivalent casting finish with minimized veining.

The principal savings generated through the use of this material is in the making of the cores and

Automated core blower has gas-heated thermostatically controlled core box. It is closed for blowing and curing.

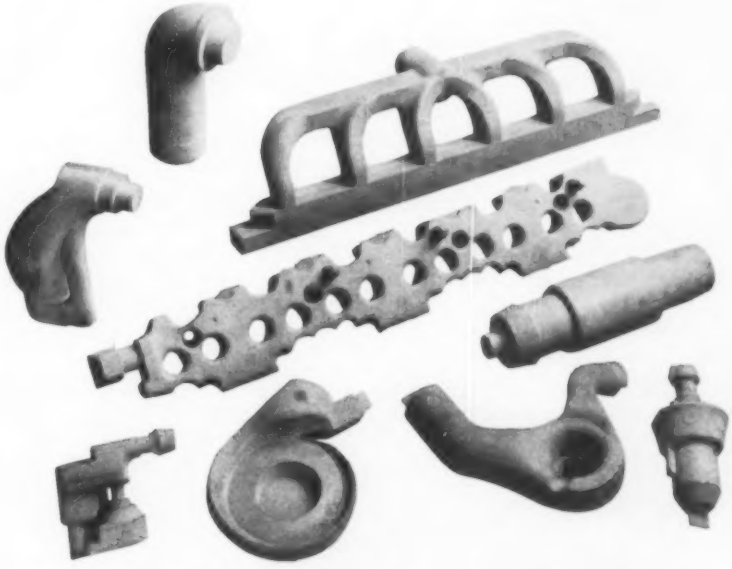
cleaning of the castings. For example, the savings accrued by switching water jacket cores from oil sand to furfural are phenomenal. Some of the larger jackets at the Milwaukee foundry required as many as 31 core wires of three different diameters. These wires had to be cut to size, bent to shape, placed in the cores, and then removed by hand in the cleaning room. It is estimated that the elimination of these wires through the use of furfural cores will result in a 20 per cent reduction in cleaning costs on cylinder heads.

Further savings will be made in the core room through the elimination of driers, since the core is hardened in the box. With no driers to be tied up in long baking cycles, scheduling problems will be materially eased and lead times reduced.

In addition to the benefits of reduced costs and higher production rates, International Harvester feels that the better dimensional control obtained through the use of such cores will result in an improvement in quality and product reliability.

It should be emphasized that this is not a universal process . . . . there are a lot of cores that are better made in oil sand or in shell sand for reasons such as size, casting finish desired, or low production requirements. However, the process is adaptable to many types of cores, and the use of this technique will make it possible for foundries to provide a better casting at a lower product cost.

Three separately blow cores are assembled to form this intricate core cavity.



Representative collection of furfural cores currently produced by hot core box method.

Within 15 seconds after blowing, core box opens and ejection pins release cores from cavity.

Instant Power . . . For Standby Emergencies

Standby 2000 KW generators, vital links in our national defense's early warning system, must stand ready to "turn out the power" on a moment's notice in sub-zero climes.

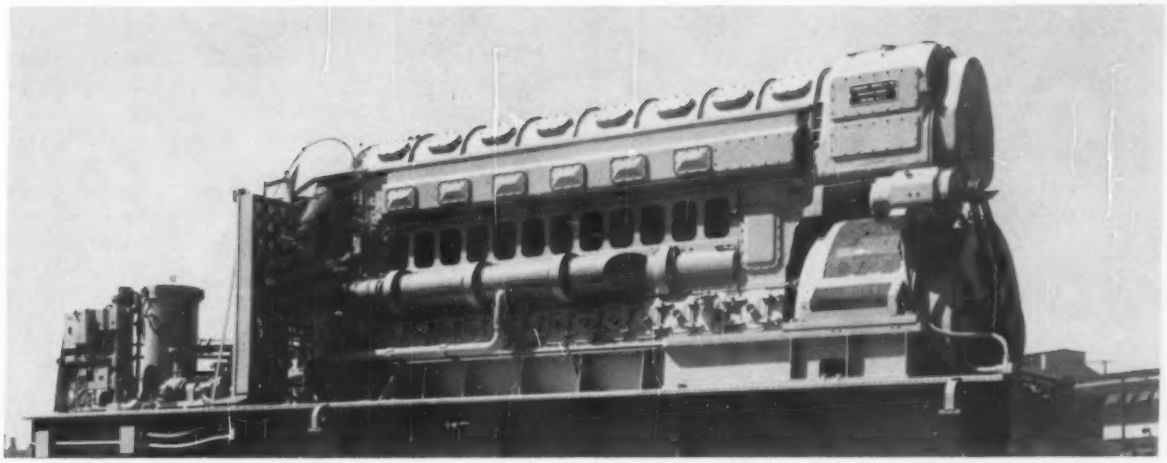
Engines (12-cylinder, 2500 hp diesel units) have been developed to drive these behemoth power plants, peaking the power output within 30 seconds after start up.

Because of the tremendous force and torque of these instant power drives, castings are used for crankshafts, cylinder liners, pistons, exhaust ports, piston inserts, and other critical parts of the engine. Buford Huffman, foundry superintendent, Fairbanks, Morse & Co., supplied production details.

Open cope and drag mold with cores in position for cast cylinder liners. Green sand mold is torch-dried, prior to pouring 1100 lb of iron.

GRAY IRON CASTINGS perform many critical functions in turbo-supercharged engines. Castings are used for crankshafts, cylinder liners, pistons, exhaust ports, and piston inserts. A cast aluminum blower housing and two cast aluminum rotors go into each blower supplying air for combustion. Some installations have been equipped with a 2750 pound ductile iron extension shaft which links power unit and electric generator. Formerly a steel forging, this shaft is coupled directly to engine crankshaft so it takes the full torque loading accompanying high speed acceleration. All castings are made in Fairbanks, Morse & Co. foundry in Beloit.

Six of these powerful FM engines, weighing 114,000 pounds each, have just been shipped to Thule, Greenland, to serve as a standby plant for the Ballistic Missile Early Warning System. In case of power failure from the prime



Finished instant power unit is shipped completely assembled and ready for installation at the Ballistic Missile Early Warning system at Thule, Greenland. Blower assembly is located at upper right section.

source, 12,000 KW of power can be made available within 30 seconds by this instant power installation. Operated by the U. S. Air Force, the Thule base is located only 900 miles from the North Pole where temperatures drop to −65 F and winds reach 185 mph.

Uses for Standby Units

Other uses for instant power standby units include: Atomic submarine tenders; public utility generator plants; industrial plants with critical processes dependent on electricity; and telephone, radio, television, and telegraph stations. Some of the engines are so fast they have been able to reach peak power output within 8 seconds! The compact design of this turbosupercharged opposed piston engine gains 50 per cent more power per square foot of floor area, 35 per cent more power per pound of engine, and 5-10 per cent less fuel consumption than other units.

Every casting going into these highly engineered power units must meet rigid requirements of high integrity service. No salvage repairs are permitted on the critical castings. They are either perfect or scrapped. Many castings going into this instant power unit had to be redesigned to withstand the higher temperatures and pressures accompanying the turbo-supercharged innovations.

Metallurgical properties are such that all the iron alloys are cold melted in an electric arc furnace holding a 16,000 pound charge. Each type of casting (crankshaft, liner, and piston) is poured from its own custom engineered alloy. The crankshaft metal is a highly alloyed acicular iron. This iron has a 70,000 psi tensile strength and 285-300 Bhn. Each chemical element is spectrographically checked before tapping and controlled to within ±0.10% of specification. Liners are cast in a low carbon Cr-Ni-Mo iron with a 50,000 psi tensivel and 300 Bhn (max). Pistons are poured with a different Cr-Ni-Mo iron having 35,000 psi tensile strength and, 241-285 Bhn.

Good Refractory

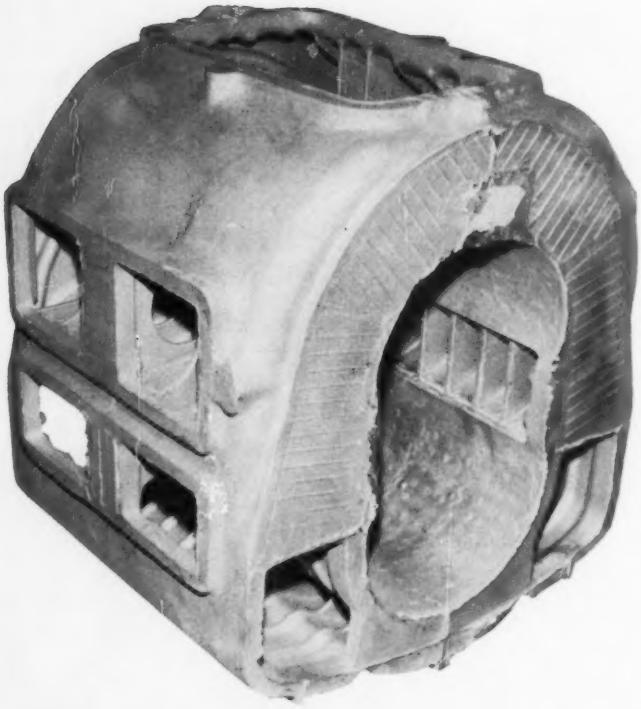
Because the electric furnace alloys are poured about 150 F hotter than normal gray iron, molds and cores must have good refractory properties. To hold accurate dimensions and thereby reduce machining, some molds are dry-sand and oven baked. Others are torch skin-dried to a substantial depth. All mold and core surfaces are coated with a refractory wash.

Crankshaft molds are made with a sandslinger. Chills are liberally used to guarantee dense metal on critical surfaces such as bearing and crankpin journals. Over half of the mold surface is occupied with chills which are wired to flask cross bars. Crankshafts are cast hollow—38 cores being required in certain cranks. Mold is poured horizontal with a runner box at each end. Each box contains two plugs so four runner systems are acting simultaneously as metal is poured from two ladles. About 7000 pounds of metal are poured at 2800 F for a 12 cylinder crank.

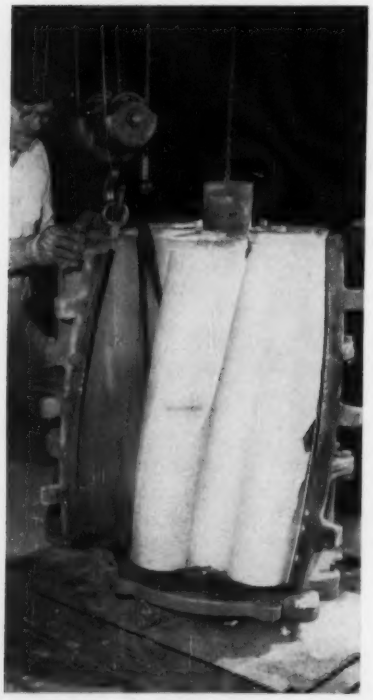
Use of Chills

Three test bars are attached to riser and runner bar. Shipping weight of the crankshaft is 3425 pounds. Two cylinder liners are cast in a mold which is made by jolt squeeze in a 48 x 60 x 20/20 inch flask. Again heavy use of chills is made to gain wear resistance. The mold wash is ignited and mold further dried by torch. About 1100 pounds of iron are

Extensive use of metal chills to produce dense iron creates a number of fins which must be removed from 305 lb cast cylinder liner.



Each instant power unit is equipped with a large blower. Shown is aluminum blower housing weighing 1050 lb.



Each blower is equipped with 2 aluminum rotors weighing 313 lb each and cast in a permanent mold.

poured at 2700 F. Finished weight of a liner is 305 pounds.

Pistons are poured in green sand, four to a mold. Molds are made on jolt, squeeze machines, and 540 pounds of iron are poured at 2650F. Final piston weight is 70 pounds. Also cast in gray iron are 135 pound exhaust ports and 30 pound piston inserts. Most of these castings are stress relieved before machining.

The 1050 pound blower housing is poured in a dry sand mold with aluminum alloy SAE 35 melted in a gas fired furnace. Each blower requires two aluminum rotors weighing 313 pounds apiece. These are cast in a permanent mold also using alloy SAE 35.

Fairbanks is taking a close look at ductile iron castings for further applications. Already in use on certain marine engines are ductile iron pistons, exhaust ports, manifolds, cylinder liners, pipe fittings.

Gray Iron has lost out in one important application—and that is the cylinder block. It is fabricated from flame-cut, heavy steel sections, sturdily welded into an exceptionally compact, light weight, rigid unit. Weight was reduced 35 per cent by switching from cast gray iron block. This design also met the "shockproof" construction requirements of the U. S. Navy.

Since the development of the opposed piston diesel engine 25 years ago FM has installed nearly 8 million horse power in marine, locomotive and stationary applications. In this same period Fairbanks, Morse has demonstrated their confidence in metalcasting by using millions of pounds of cast components in these installations. Today, the castings used in the most modern "instant power" engine proves their belief in the relibility and economy of cast metals.

Machinist supervising automated boring mill finishing the inside contour of cylinder liner.

FROM CANADA

How to Grain Refine High Silicon-Aluminum Alloys

- *Inherent coarse grained structure of this alloy has discouraged its use for many years because of difficult machining.*
- *A new refining technique now makes the metal commercially useable for numerous cast engine parts.*

by J. SULZER, METALLURGIST
Aluminum Laboratories, Ltd.
Kingston, Ontario

GOOD WEAR RESISTANCE and low thermal expansion make hypereutectic aluminum-silicon alloys an ideal material for the automotive industry. Typical applications include air-cooled engine cylinders, cylinder sleeves, pistons and brake drums (or liners). Poor machineability, arising from its coarse grain structure, deterred commercial acceptance of the casting alloy. Recent research reveals that addition of 0.10-0.16 per cent phosphorus refines the silicon so it is now a promising engineering material.

High silicon-aluminum alloys have been in use in Germany for many years. In the late 1930's our associated company (Aluminiumwerke Nuernberg G.m. b.H., Nuernberg, Germany) introduced a 17 per cent silicon-containing alloy for use in pistons. Alloys with higher silicon content attracted limited interest, at that time, because of machining difficulties.

These difficulties existed because a suitable treatment for refining the alloys structures was lacking. However, with the development of a satisfactory refining treatment, several years ago, higher silicon alloys became practical. For example, a 23 per cent silicon alloy was put into commercial use by this same company about five years ago. It was prepared particularly for pistons requiring a still lower coefficient of thermal expansion than is obtainable with 17 per cent silicon alloy[1].

Normally, when hypereutectic aluminum-silicon alloys solidify, the primary silicon crystals grow to a considerable size and segregate to some extent. A treatment with phosphorus results in a refinement of the primary silicon phase.

According to Lund[2], phosphorus combines with aluminum to form aluminum phosphide, which has a lattice structure and parameter similar to silicon. Nuclei of aluminum phosphide act as growth centers

Table1—The Effect of Sodium and Calcium Content of the Metal on the Degree of Refinement of Primary Silicon

Melt Ident.	Na Content before Nucleation (%)	Na Content after Nucleation (%)	Ca Content before Nucleation (%)	Ca Content after Nucleation (%)	Average Dimension of Primary Silicon (microns)
GKE	⩽ 0.001	⩽ 0.001	⩽ 0.001	⩽ 0.001	25
GQG	0.007	0.004	⩽ 0.001	⩽ 0.001	35
GQH	0.008	0.003	⩽ 0.001	⩽ 0.001	32
GQK	0.015	0.008	⩽ 0.001	⩽ 0.001	45
GQI	⩽ 0.001	⩽ 0.001	0.004	0.002	25
GQJ	⩽ 0.001	⩽ 0.001	0.019	0.011	30
GQO	0.017	0.006	0.011	0.005	35

for the primary silicon particles. They produce finer, more numerous, and more uniformly distributed crystals in the structure. The result of such a refinement is a considerable improvement in machinability[3], and to some extent an improvement in mechanical properties, thermal conductivity, and linear thermal expansion.

Quite frequently small amounts of sodium and calcium are encountered in aluminum-silicon alloys. They are potentially troublesome because they can form phosphides and thereby remove phosphorus during the refining treatment. This results in a coarser, less uniform structure. Melts containing various quantities of these elements, prior to refining, were investigated to determine permissible amounts that would ensure consistently good refinement.

In the production of castings, melts sometimes are held for extended periods and certain quantities of metal must be remelted. Therefore, the possibility of a loss of phosphorus, and consequently a loss of refinement, must be considered. Such losses would vary from foundry to foundry, for differences prevail in melting practices, holding periods, and amounts of gates, risers, and scrap castings recycled. Therefore, no single set of data can be presented which is universally applicable. However, results will be shown for a particular set of holding and remelting conditions to illustrate the trend of the refinement change.

Castings usually consist of sections of different thicknesses, freezing at different rates. Conditions affecting the freezing rate can vary considerably. Factors such as mold material and design, mold temperature, metal temperature, type of mold wash, thickness of mold wash affect the actual heat transfer rate. Since these differ for each type of casting, in the work reported here, the actual freezing rate was determined and the degree of refinement compared with it and with section thickness.

In addition, the tensile properties and hardness of X-1110 alloy were determined for various types of heat treatments. Included were the as-cast condition, a precipitation heat treatment, and a solution plus a precipitation heat treatment. Also, to illustrate the improvement in machinability achieved by good refinement, tool wear was measured for non-refined and well refined structures.

A sodium content of only 0.007 per cent increased the average dimension of primary silicon from 25 microns (which is considered to be a relatively well refined structure) to 32 microns, a medium refined structure. Twice this amount of sodium, 0.015 per cent, resulted in poor refinement; that is, an average dimension of the order of 45 microns. A calcium content of 0.019 per cent resulted in coarsening the primary silicon particles only a small degree.

The presence of both 0.017 per cent sodium and 0.011 per cent calcium is not more deleterious than this amount of sodium alone. In production, a short chlorine fluxing treatment prior to, or during, nucleation of the melt reduces the level of these impurities to 0.001 per cent or less, thereby ensuring consistently good refinement.

During the first five hours of continuous holding, the mean dimension of primary silicon particles increased from 22 to 32 microns. After remelting and another five hour period, it increased to 48 microns. During a third holding period no further coarsening took place. Remelting itself did not contribute to a further loss of refinement. Similar trends were found by others[5].

These data suggest that to ensure a well-refined structure some further nucleation is required after several hours holding, or upon remelting metal which has been held for a similar time. Production experience has shown that the use of 25 to 50 per cent of the normal nucleating addition for the scrap portion of the charge, and the full amount for the untreated portion, is generally satisfactory. As discussed earlier, each foundry must check the effect of its own practice to establish when re-nucleation is necessary.

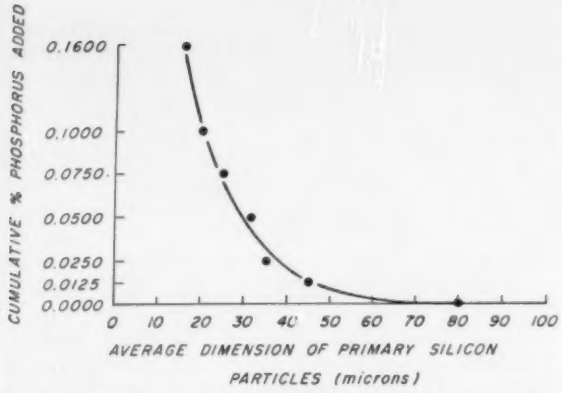
A rather gradual increase of freezing rate occurred with decreasing plate thickness. Only the 3/16-inch

Table 2—The Effect of Holding and Remelting X-1110 Alloy on the Degree of Refinement of Primary Silicon

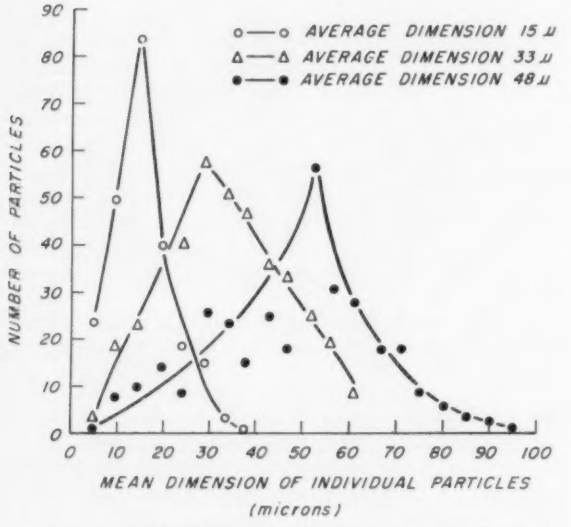
Sample Identification	No. of Remelts	Holding Time (hours)	Average Dimension of Primary Silicon (microns)	Magnesium Content %
GNH-1	0	0	22	1.22
-3	0	1	25	—
-5	0	2	27	—
-7	0	3	29	—
-9	0	4	31	—
-11	0	5	32	1.08
-15	1	0	32	0.98
-17	1	2-1/2	28	—
-19	1	5	48	0.86
-21	2	0	34	0.86
-23	2	2-1/2	43	—
-25	2	5	43	0.75

Table 3—Mechanical Properties of X-1110 Alloy Permanent Mold Test Bars

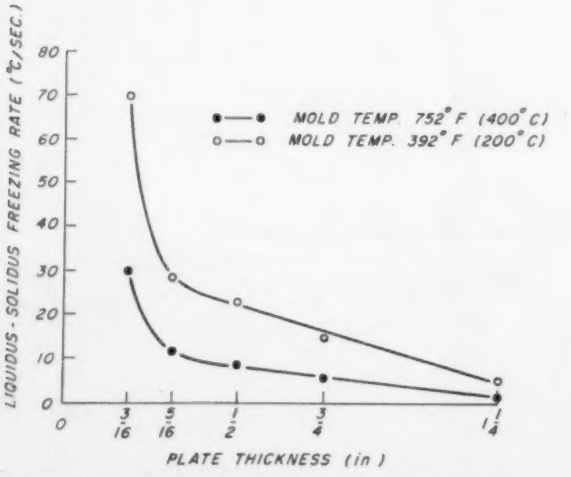
Temper Designation	Particulars of Heat Treatment	Average Mechanical Properties				
		Ult. Tens. Strength (ksi)	0.1% Yield Strength (ksi)	0.2% Yield Strength (ksi)	Elong. (% on 2 in.)	Brinell Hardness 10/30/500
F	as-cast	28	20	24	1 to 2	100
T5	6 to 12 hrs. at 400 F (200 C)	31	28	30	1/2 to 1	105
T7	5 hrs. at 930 F (500 C), hot water quench, 6 to 12 hrs. at 400 F (200 C)	40	38	—	1/2 to 1	125



1. Results demonstrate effectiveness of increasing phosphorus additions in refining primary silicon.


AVERAGE DIMENSION 15 μ
AVERAGE DIMENSION 33 μ
AVERAGE DIMENSION 48 μ
NUMBER OF PARTICLES
0 10 20 30 40 50 60 70 80 90 100
MEAN DIMENSION OF INDIVIDUAL PARTICLES (microns)

2. Frequency distribution curves are typical of good, medium, and poor refinement. Good refinement consists of a smaller average dimension and a narrower mean dimension range of individual sections exposed.


MOLD TEMP. 752° F (400° C)
MOLD TEMP. 392° F (200° C)
LIQUIDUS - SOLIDUS FREEZING RATE (°C/SEC.)
80 70 60 50 40 30 20 10 0
3/16 5/16 1/2 3/4 1 1/4
PLATE THICKNESS (in.)

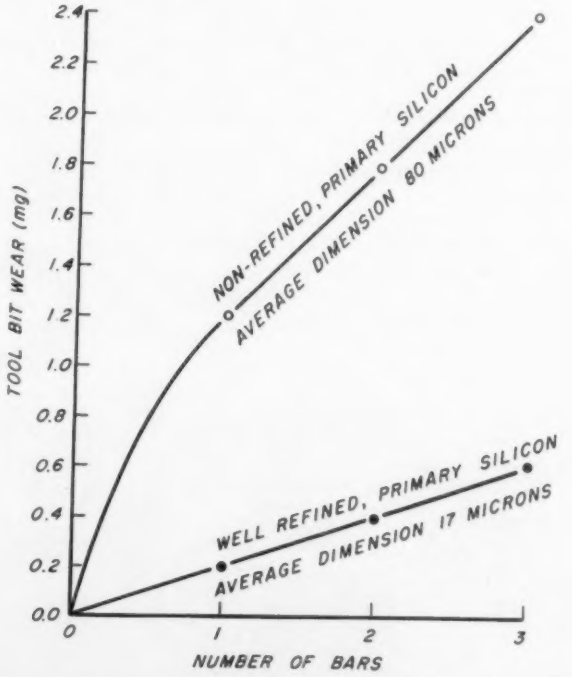
3. Liquids-solids freezing rates encountered with various plate thicknesses.

plate poured at a mold temperature of 392 F (200 C) departed from this trend because of the much greater freezing rate. This is generally representative of die cast sections and thin sections in permanent mold castings.

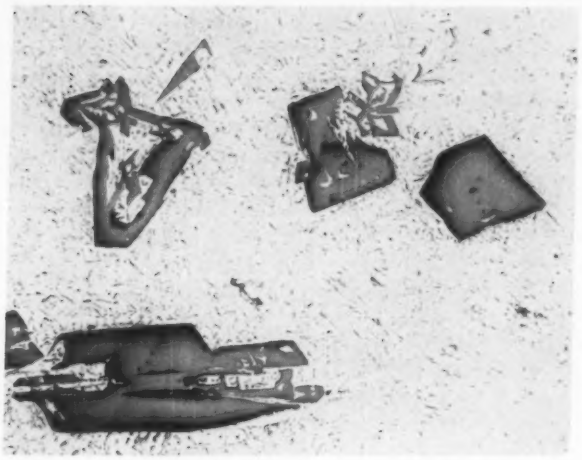
In the range of freezing rates from 5 to 50 F per second (2 to 30 C per second), a very marked and consistent decrease in average dimension of primary silicon particles occurs as the freezing rate increases. With rates greater than 50 F per second (30 C per second) very little further refinement of primary silicon takes place. In general, the range of average particle dimensions attainable with good refining practice varies from 23-31 microns for low, to 14-18 microns for very high freezing rates.

Also noteworthy, is the effect of freezing rate on the eutectic structure. Freezing rates less than 40 F per second (23 C per second) cause no appreciable refinement. Rates greater than this produce progressively finer eutectic structures. In producing die castings of 3/32-inch thickness, dimensions of 10 microns have been observed, and for 1/4-inch thick sections 15 to 20 microns are prevalent.

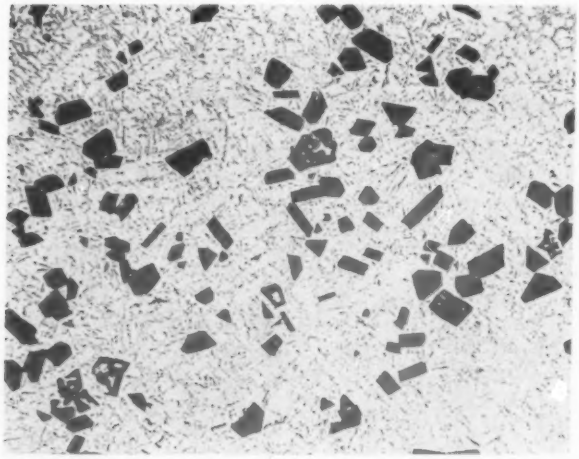
Substantial increases in ultimate and yield strengths are achieved by either a precipitation heat treatment or a combined solution and precipitation heat treatment. The ductility of this type alloy is low in any condition, due primarily to the presence of such a large quantity of insoluble constituents. However, this is not a general purpose alloy, but useful only in applications where its low ductility can be tolerated and low coefficient of thermal expansion and good wear resistance are important. The hardness is also increased by heat treatment, particularly if a solution and precipitation treatment are used. These


TOOL BIT WEAR (mg)
2.4 2.2 2.0 1.8 1.6 1.4 1.2 1.0 0.8 0.6 0.4 0.2 0.0
NON-REFINED, PRIMARY SILICON
AVERAGE DIMENSION 80 MICRONS
WELL REFINED, PRIMARY SILICON
AVERAGE DIMENSION 17 MICRONS
0 1 2 3
NUMBER OF BARS

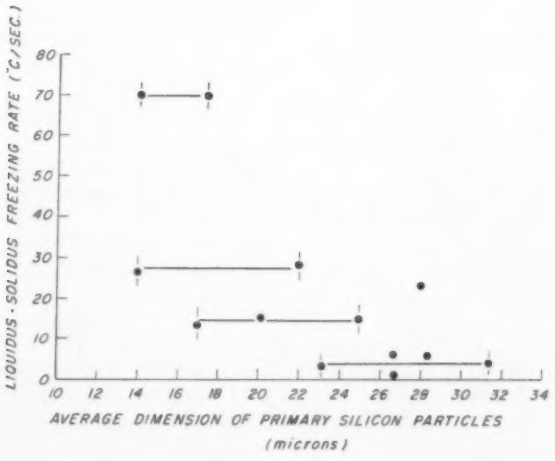
4. Extent of improvement in machinability of alloy achieved by refining its structure.



Photomicrographs show the various degrees of refinement: hexagonal, triangular, rectangular, and square cross-sections of the various sizes exposed. The larger the particles, the wider the range of sizes.



Refinement is attributed to titanium salt in the nucleant used. By virtue of its grain refining ability, titanium has affected the eutectic solidification, preventing a coarse silicon formation in the matrix.



5. Graph shows effect the liquidus-solidus freezing rate has on the degree of refinement. Even with very low rates, such as 3/4 and 1-1/2 inch sections, the primary silicon is quite well refined with the particular phosphorus addition used.

values are in agreement with the properties reported by others[1,5,6].

1. To obtain reasonably good refinement of the primary silicon phase in X-1110 alloy, an addition of at least 0.025 per cent phosphorus is required. To attain a well refined structure an addition in the range of 0.10 to 0.16 per cent is required.

2. The measurement of primary silicon particles exposed on a metallographic specimen, expressed as the average dimension supplemented by a frequency distribution, is a suitable method for comparing various degrees of refinement.

3. To obtain consistently good refinement of the primary silicon phase in X-1110 alloy, the sodium content must be held to a maximum of 0.001 per cent; calcium to a maximum of about 0.004 per cent.

4. Prolonged holding of nucleated X-1110 alloy melts at 1400-1418 F (760-770 C) results in slow progressive coarsening of the structure and also causes continued loss of magnesium; the remelting operation itself does not affect the degree of refinement.

5. High freezing rates in the liquidus-solidus temperature range greatly improve the degree of refinement of primary silicon in nucleated X-1110 alloy. However, even with very low rates the refinement is good.

6. The ultimate strength, yield strength and hardness of X-1110 alloy are increased considerably if given a T5 or T7 type heat treatment but the ductility is low in any condition.

7. Tool wear is reduced considerably by refinement of primary silicon; machinability is improved.

Experimental Procedure to Determine Grain Refinement

Melts of 50 to 100 lb of X-1110 alloy were prepared in a gas-fired crucible-type furnace using standard hardener alloys for silicon, manganese, and iron, and pure metal additions of magnesium and copper. The nominal composition of this alloy is 20.0% Si, 1.0% Cu, 1.0% Mg, 0.5% Fe, 0.5% Mn, balance Al. The refining treatment was carried out at 1400-1418 F (760-770 C) using a patented[4] nucleating agent composed of red phosphorus and titanium and potassium salts. All melts were chlorine fluxed for 10 minutes prior to nucleation.

A permanent mold test bar was the form of sample used for some of the work. The mold used is that called for in the Canadian Standards Association Specification H.A. 1.5 (1948). A pouring temperature of approximately 1380 F (750 C) was used throughout this work. The mold temperature was adjusted to 608-626 F (320-330 C) prior to pouring each test bar. The time taken to fill the mold was approximately 5 seconds. All bars for tensile tests were radio graphed. Bars sound in gauge section were used.

To establish the extent of refinement of primary silicon by increasing amounts of phosphorus, successive additions of nucleant were made. These totalled 0.16 per cent (by melt weight) phosphorus. After each addition, two permanent mold test bars were poured. Sections from the gauge lengths served as samples to evaluate the microstructure for the structural refinement attained.

Test bar gauge sections also served as samples for determining the effect of sodium and calcium on the refinement. Metallic sodium and/or calcium were added before the nucleant which contained 0.16 per cent (by melt weight) phosphorus. Time lapse before nucleating was 10 minutes. After adding the nucleant, melts were held 5 minutes and then test bars were poured. Sodium and calcium contents of melts were determined spectrographically before and after nucleation. Two levels of sodium, 0.007 and 0.015 per cent; two levels of calcium, 0.004 and 0.019 per cent; and one combination of these elements, 0.017 per cent sodium plus 0.011 per cent calcium were investigated.

The effect of holding and remelting was established over three successive five-hour holding periods. After each such period the metal was poured into ingot molds and remelted for the next holding period. Holding temperature was controlled at 1400-1418 F (760-770 C). Two test bars were poured every hour during the first five-hour period, but only every 2-1/2 hours of the second and last periods. The amount of nucleant added at the outset of the test contained 0.16 per cent (by melt weight) phosphorus and no subsequent additions were made.

To determine the effect of freezing rate on the structure, a special steel mold was employed. The book mold was fitted with inserts which restricted the mold cavity to give 6 by 4-inch plates, 1-1/4, 3/4, 1/2 and 5/16 inches thick. A smaller plate 4 by 3 by 3/16 inches was cast in a similar mold, normally used to cast specimens for chemical analysis, since it was considered impracticable to run a 3/16 inch thick plate in the larger size.

The amount of nucleant added to each melt used in these tests contained 0.16 per cent (by melt weight) phosphorus. Metal pouring temperature was adjusted to 1400-1418 F (760-770 C), the temperature range generally used for this alloy in production of castings. Mold temperature was held at 392 F (200 C) for one series, and at 752 F (400 C) for another series of plates. This attained a wide range of freezing rates similar to that encountered in production.

A thermocouple, centrally positioned and held with a chaplet midway between the side walls of the mold was cast in with each plate. An electronic recorder attached to the couple gave a continuous record of the freezing rate. Average freezing rates over the liquidus-solidus range were determined from these charts. The nucleation and growth of the primary silicon particles is influenced by the cooling rate only through this particular stage of solidification. The microstructure was checked on sample sections cut from each plate 1/8-inch below the thermocouple bead.

The refinement of primary silicon was evaluated by a comparison-to-standards method. This permits a rapid determination of the average particle size in samples from castings. These standards have been arrived at by measuring the mean dimension of at least 200 particles exposed on a polished metallographic sample, then calculating the arithmetic average of these mean dimensions. To prevent any tendency of the part of the measurer to select certain crystals, all particles intercepting an eye-piece micrometer scale were measured at a magnification of 125X and recorded.

To illustrate the improvement in machinability, as it affects tool wear, attained by refining this type of alloy, the following test was carried out. Ten 1-inch diameter bars, 18 inches long were cast in a graphite mold. Five were unrefined, and five were refined to the maximum degree attainable. Using a cemented carbide tool bit, forty 0.010-inch cuts on the diameter were made over ten inches of each bar. Then the weight loss of the tool bit was used as a means of measuring tool wear. Machine speed was 2000 rpm at a feed of 0.003 inches per revolution. Tool angles were as follows: Back rake, 5 degrees; side rake, 11 degrees; end relief, 18 degrees; side relief, 13 degrees; end cutting edge, 16 degrees; side cutting edge, 12 degrees; and practically no nose radius. Tool holder angle was 13 degrees. Although the use of a lubricant is essential for this type of alloy, none was used for this test in order to induce maximum wear within a reasonably short time.

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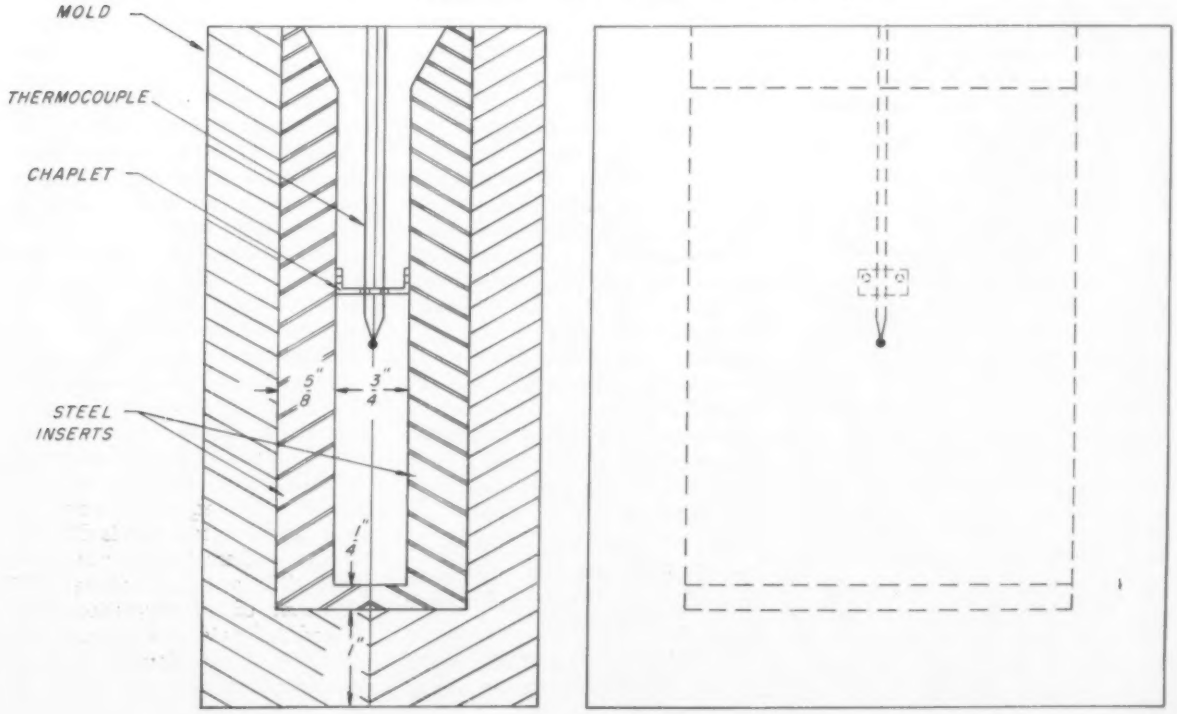
(5) J. Koritta and A. Franek, "Modification of Hypereutectic Al-Si Alloys with Phosphorus Pentachloride", Hutnicke Listy, XIII, No. 12, (1958), pp 1081-1086.

(6) R. M. Smith, "Hypereutectic Aluminum-Silicon Alloys", SAE Preprint 65A (1958).

(7) O. Tichy and R. Kissling, "A Hypereutectic Aluminum-Silicon Alloy", Modern Castings, Vol. 35, No. 6, (June 1959), pp 67-72.

6. Freezing rate on structure is determined by use of a special steel mold. Inserts are for 3/4" plate.



How to Operate a Successful Suggestion System

by Bill Walkins
Esco Corporation
Portland, Oregon

In a competitive business like ours, we need the thinking of every person in our organization. There are many discerning people on our production team. It's up to us to give them the proper incentive to submit suggestions—James T. Dorigan, chairman, suggestion committee at Esco Corp.

Not long ago, Mike Ernst and his wife boarded a plane at Portland, Oregon for a two-week vacation trip through Eastern and Southern United States. All expenes were paid by Esco Corporation (formerly Electric Steel Foundry Company) where Ernst is employed as a leadman coremaker. The trip is the annual grand prize awarded by the company for the year's best suggestion.

Ernst came up with an idea for an arrangement of sand chutes and conveyor systems that revolutionized operations in his department. He was the tenth person to win the prize trip since the company inaugurated the program in 1950. The first such award was for a reversible permanent pig mold in the stainless foundry. Trip winners are chosen by a special committee from the four winners of the quarterly awards, the latter consisting of a new suit and top coat.

Esco Corporation maintains a sizeable foundry operation at Portland, Ore., plus a manufacturing plant at Danville, Ill., and offices and warehouses in principal cities of the United States, including Hawaii. A sister firm, Esco Limited, has a foundry in British Columbia, a manufacturing plant in Toronto, Ontario, and sales offices throughout Canada. Worldwide distribution of Esco products is handled through Esco International, with offices in Portland and New York City.

This diversity provides a wide latitude for suggestion ideas. The Danville and Canadian operations have their own suggestion committees. The remainder is handled by the committee at Portland.

Esco's suggestion program got under way in July, 1944. Like most firms, it operates within the framework of the National Association of Suggestion Systems, of which it is a member. NASS rules are sufficiently flexible to allow a firm to preserve its autonomy and at the same time develop suggestion regulations to fit the company personality. Consequently, any firm may have a system that is different from all others in many respects.

In 1959, our firm adopted 35.7 per cent of all suggestions submitted and paid an average award of $33.09. Our employees submitted suggestions at the rate of 919 per

thousand employees, compared to an average in the metalworking industries of 264, and 172 for industry as a whole.

James T. Dorigan, who is permanent chairman of the suggestion committee (and is, incidentally, a past chairman of Oregon Chapter, A.F.S.) attributes this large volume of response to the fact that Esco pays 20 per cent of the first year's savings on suggestions where savings can be figured. Also the company is very generous in cases where the suggestion has intangible benefits. It also pays a minimum award of ten dollars—something that is not commonly done by other firms.

"The percentage of accepted suggestions might be even larger," says Dorigan, "except that some employees find the suggestion system a convenient way to air their gripes. There is nothing particularly wrong with this, as it generally results in the complaint being taken care of to the mutual satisfaction of the company and the aggrieved individual. But the suggesters in such cases seldom expect to receive an award, and it adds to the list of 'no award' numbers".

When an employee has an idea, he finds supplies of suggestion blanks available near his work station. He drops the suggestion in any one of many suggestion boxes scattered liberally about the plant and office.

How It Works

The suggestion form is numbered. A stub bearing the same number is detached by the suggester and held for identification. He has his choice of signing his name to the suggestion or of remaining anonymous.

The boxes are opened weekly and contents taken to the secretary of the suggestion committee. Each suggestion is typed on another form which is sent to the supervisor of the department involved. He is asked to comment on the worthiness and workability of the suggestion.

The suggestion committee meets once each month. It considers every new suggestion and makes decisions on those that were held over from the previous month. Committee members include the permanent chairman, two plant supervisors and two production workmen. The supervisors serve for six months and the line workers for a term of one year. Suggestions are discussed one at a time and processed in one of several different ways, depending on the nature of the suggestion.

Small suggestions having merit may be accepted immediately and the minimum award of $10 paid. Others having greater merit but on which savings cannot be figured may also be accepted, or may be deferred for trial until a fair amount of reward can be determined. In cases where a saving can be determined in dollars and cents, a suggestion might be granted a preliminary award, with the balance (20% of the savings for the first year) paid after the accounting work has been done.

Collecting the Award

Another possibility is that the committee might disagree with the department supervisor on the workability of a suggestion. In this case the suggestion is held for trial and investigation, and if it proves workable a suitable award is granted.

Complete minutes of the suggestion committee meetings are posted as soon as possible at designated places throughout the plant. The minutes contain the decisions on each individual suggestion, together with the amount of award if accepted, and if not, the cause for rejection. Rejections are carefully worded to avoid possibility of resentment or humiliation.

In addition, numbers of winning suggestions are posted on bulletin boards, and a brief resume of the month's suggestion business is published in the company magazine, together with photographs of the more interesting winners.

Upon receiving the news that his suggestion has been accepted, the employee writes his name on the numbered stub and turns it in to the timekeeping department. When the checks are ready a top official of the company delivers them directly to the people involved, together with his personal congratulations.

Any employee may make suggestions relating to his own job or to any other part of the operation. Salaried supervisory people are not eligible for awards on suggestions originating within their own departments, but may be compensated for ideas on improvements or better methods in some other department.

About two years ago the company instituted a work simplification program under the direction of Jack Sieforth, training coordinator. Using as its slogan, "Work Smarter, It's Easier", this technique combines ideas of working teams to formulate time and cost saving methods.

The two programs dovetail nicely, and suggestions emanating from work simplification teams are considered and awarded by the suggestion committee. Awards are divided among the work simplification participants.

Even though the suggestion committee states on the printed form that its decisions are final, in the interest of fairness appeals are regularly heard and adjustments made. A suggester may appeal if he believes his award was not large enough. If investigation proves him correct, he is granted an additional award. Cases may arise where a suggestion was rejected, but methods put into effect at a later date might involve this suggestion or an adaptation of it. Upon producing evidence that the original idea was his, the suggester would be rewarded accordingly. As a result of this policy the committee has had very few claims of insufficient awards or unfair treatment.

System Worth the Price

The lowest suggestion award ever paid was five dollars—the established minimum at the outset, later raised to ten dollars. The highest award to date has been $1200 for an idea to use a less costly type of ferro-alloy. The latter award was parlayed to more than two thousand dollars, since the suggestion received a quarterly award and the suggester also won the annual grand prize trip.

In the thirteen years since its inception, the Esco suggestion program has paid for ideas ranging from a simple pattern alteration to the remodeling and reorganization of an entire shop department. In the opinion of the firm's top management people, the program is well worth the time and money.

Key Metalcasting Trends as Revealed at Zurich

An analysis of world-wide foundry technology by James Vanick, AFS Gold Medal winner and top metallurgist. He interprets findings reported at I.F.C. sessions.

Melting Furnaces, Fuels, and Gases . . . R. Doat and his Belgian associates described their *metallurgical blast cupola.* Operated on a hot blast, it produces closely controlled metal at uniform temperature. Studies of blast distribution in the melting zone revealed that with a slight excess of fuel, chemical elements oxidized because they are in the blast path from the tuyeres—are reduced again by a very hot zone below the tuyeres. This leads to a smaller loss in Si, Mn, and Fe. Proving extra coke expended for this purpose can be economically justified.

There are points of similarity in Doat's work and the water-cooled hot-blast cupola described by M. E. Rollman at the 1960 AFS Convention and published in MODERN CASTINGS, Sept., 1960

Controlling metal quality by adjusting blast temperature, as reported by Rollman, resembles a carburetor adjustment. Close control of cupola ingredients and specifications are essential in seeking push-button cupola melting.

C. Podrzucki of Poland presented a mathematical expansion of his observations upon *velocity of coke combustion.* His approach defined the position of the melting zone in the cupola and its movement with changes in tuyeres and fuel.

The comprehensive mathematical treatment proposed appears to limit its application to coke experts or to testing laboratories handling large volumes, upwards of 100 tons of coke per test.

Podrzucki's experimental apparatus appears to provide an excellent device for the study of coke. When used by experts, the device and formulae would be valuable in evaluating coke, developing specifications, and prescribing usage.

The average U.S. cupola operator expects a pre-tested product made to his demands. He would consider the test and its application exhaustive.

P. Bastien of France spoke on *gases in steel.* He discussed measuring the hydrogen content at 600 C. under vacuum with a palladium filter. Also covered was the embrittlement of steel and hydrogen segregation as related to solidification.

A British investigator reported the maintenance of a 2 to 3 mm vacuum for eliminating gas. Whereas Bastien said that he expected 1 to 2 mm were used in operations he described.

Where vacuum melting is not employed, great care is exercized in choosing and handling charging stock and processing the melt to eliminate hydrogen, or to make its residual content harmless.

B. Marincek of Switzerland discussed the method and measure of the *gas content of ferro alloys.* He showed that their gas contents varied considerably and increased during storage. Principal alloys under study were ferro silicon, calcium silicide, and ferro manganese.

Processes . . . W. Gotz of Switzerland described *automatic molding machines* in which three cope and three drag units mesh their output onto a conveyor for closing, pouring, shakeout, and return.

Several of these units are under test in U.S. steel and malleable shops. Gray iron shops should give them a high priority for development.

It appears that foundry management is not ready to make high capital expenditures which trade high cost molders for high priced mechanics. The system requires much maintenance and adjustment.

E. Zingg of Switzerland described *electric furnace developments* and their expanding use to control quality and improve quality and working conditions. He proposed hollow electrodes through which inert gas such as argon may be passed. This will subdue reactions between furnace linings, slags, and harmful furnace atmospheres. Also outlined were uses on such metals as iron, steel, bronzes, etc.

Electric furnace melting or liquid metal processing units are popular in the hydro-powered Scandinavian countries as well as Switzerland and Italy. In the U.S., newer low frequency types are just beginning to make their way into foundries. The high frequency and arc types are used extensively in the U.S. for high quality alloys, steels, and premium quality castings.

G. W. Form and associates of Case Institute of Technology presented the official American Foundrymen's Society Exchange Paper. It dealt with the addition of inoculants or mechanical vibration to refine grain in cast copper, steel, and cast iron. Keen interest was exhibited in the process. However, it is not yet a commercial possibility.

N. G. Chakrabarti of India and associates described the making of gray iron automotive castings by *carburizing an all-steel charge in an electric furnace.* Limited raw material, high phosphorus pig, led them into synthetic cast iron production.

They were faced by the challenge to meet close specifications for No. 35 iron for machinable castings of 180-220 Bhn for cylinder, cylinder heads, brakedrums.

N. S. Kreschtschanowsky of Russia prepared a paper on the effect of boron, magnesium, calcium and cerium-treatment on the surface tension, grain size, mechanical and other physical properties of steel.

Properties . . . A. Collaud of Switzerland discussed *quality factors built on an equation involving carbon equivalent, tensile strength, and hardness.* These factors were re-studied for cast irons of similar composition, specially processed or inoculated, leading to an improvement of the index.

Tests compared combined carbon content, distance between pearlite plates, ferrite content, and tensile and hardness properties. This study developed the outlining and definition of a tougher, more impact-resistant product from the same composition.

This exhaustive work could be of considerable importance for those requiring a superior quality cast iron. The general discussion brought out agreements and departures from existing quality factors.

J. S. Abcouwer of Holland, related the *cooling rate effects in castings* with the properties for various sections using volume to surface ratios applied to solidification studies.

The mathematical treatment proposes a graduation of mechanical properties as derived from cooling rates. For complex castings a hardness test is recommended for assessing the strength properties. These studies on cast iron are quite general throughout the world.

Testing . . . A. Lehtinen of Finland proposed *an ultrasonic method for tracking changes in metals at liquid metal temperatures.*

Microstructure . . . R. Mitsche of Austria reported on studies of the *formation of graphite.* He concludes that the fine flake graphite in gray iron or spheroidal graphite in magnesium-treated cast iron always forms from the liquid melt.

I. Minkoff of Israel proposed that *spheroidal graphite* formed by quenching cast iron or high carbon nickel at a critical cooling rate, strongly resembled graphite produced by the freezing of alloy-treated spheroidal cast iron. His cooling rates were derived from the water quenching of pellets ranging from 0.01 to 0.15 inches in size. Most castings are considerably larger, yet the observations may some day be translated into surface speed cooling effects.

Gating, Risering, Fluidity . . . S. Morita of Japan described *four test methods for measuring fluidity.* Fluidity is better in hyper eutectic alloys because they do not expell an obstructing crystalline solid upon cooling toward the eutectic temperature.

Such data could explain some cases of casting defects. It would also exert some influence on scientific methods for evaluating gating and risering formulae employing the fluidity factor in computations.

W. Patterson and W. Koppe of Germany presented a *mathematical treatment of solidification phenomena.* The work was similar to that J. F. Wallace and associates are doing for the AFS Gray Iron Division at Case Institute of Technology.

M. Bednarik of Czechoslovokia presented a paper on *gating systems.* He concluded that multiple flow ingates provide smooth nonturbulent metal flow when worked at a velocity of 12 to 18 inches per second. A sprue cap fed by a small sprue provided the best accessories for a trap system for eliminating slag and solids. Further help was given by a swirl in the system.

Sand and Facings . . . J. M. Middleton and P. G. McIllroy of Great Britain presented a series of papers on *molding for steel castings.* It was indicated that thick coatings of highly refractory materials such as silica, alumina, and zircon are effective in preventing metal penetration under high ferro-static pressure.

This practice is necessary in production of large or heavy steel castings where the contact of hot metal with mold surface may occupy considerable time. Steel foundrymen, by checking the authors' points, will be able to adjust their mold finishing practices.

M. B. Pajevic of Yugoslavia described *molds and cores* made of quartz sand, bentonite, corn flour and molasses bonded with sodium silicate. No CO_2 was used. Air-dried elements of this type perform satisfactorily and are easily cleaned.

Non-Ferrous Castings . . . K. Marechal of Hungary discussed use of *aluminum dies for producing die cast aluminum pistons.* Using aluminum instead of cast iron gave the permanent mold a 20 per cent improvement and a 30 per cent deepening of the chill. It is possible that die coatings used and damage to dies would require a study to establish whether the moderate quality improvement offsets the potential increase in costs.

Aluminum dies have been used for experimental explorations of various alloys, additional work such as by Marechal may bring further revelations.

L. Ekbom of Sweden described the importance of an *increase in lead content to eliminate shrinkage and leakage in 85-5-5-5 composition.* He used solidification studies in which a lead precipitation was timed to occur at the conclusion of maximum solidification for each composition. He recommended a 6.5 lead content in the presence of 5 per cent tin.

A higher tin content tended to be unfavorable. Many additional factors are involved in a study of this type and further consideration needs to be applied.

Alloy systems in the family are receiving considerable attention. Modifications made for developing improved soundness could be justifiably made for specific castings if the author's work is proven.

Trends Revealed at IFS Sessions

A U.S. symposium on vacuum melting would aid in evaluating the degree of importance and extent of corrective measures.

The thermo sonic measuring method may provide an additional tool for the study of solid or metallic systems.

U.S. work in the area of studying the gas content of ferro alloys should be re-appraised and methods found for decontaminating the alloys.

The automatic production of small castings will some day be commonplace.

Further knowledge of measuring fluidity could explain some cases of casting defects.

Bright Future Forecast for Aluminum Castings

- *Industry leaders predict up to 300 per cent growth in next 5 years.*
- *Applications are almost unlimited where lightweight and corrosion resistance are needed.*
- *New technology is being paced by quality requirements of discerning buyers.*

Reported by JACK H. SCHAUM

IF GROWTH IS the barometer of industrial vitality then the aluminum casting industry is undoubtedly the epitome of success. Proof: aluminum casting shipments have more than doubled in the last 10 years. Shipments in 1949 totalled 152,205 tons; in 1959, 393,200.

Key leaders in the aluminum castings industry, contacted by MODERN CASTINGS, were unanimously optimistic about the future. When asked to estimate growth for the next 5 years, these men predicted increases of 10%, 20%, 40%, 50%, 100%, and even 300% in aluminum casting outputs. These estimates weighed heavily on the continued expansion of uses by the automotive industry.

E. C. Kron says: "In addition to aluminum engine blocks there is also the probability of using aluminum castings for intake manifolds, cylinder heads, brake housings and even wheels. The aluminum requirements for the automotive industry in the next five years can, therefore, be expected to increase about 350,000 tons. And the greater portion of this additional aluminum will be in the form of castings."

Die casters are particularly optimistic at this time because they currently represent the ultimate in mass production. Die casting is a high speed, mechanized, automated, quality controlled operation meeting the needs of the new industrial explosion. Hidden in the 267% growth demonstrated by the aluminum casting industry in the period 1949-1959 are some significant facts revealed in the following breakdown of production processes:

Note that in the 10 years, die casting has grown 418%, permanent mold 267%, and sand casting only 133%.

T. D. Stay, Reynolds Metals Co., optimistically predicts the figures appearing in the column marked "1965". These predictions show again that the most dramatic growth is expected in permanent mold and die casting.

Concurring, the Commercial Research Department of the Aluminum Company of America states: "While the economic climate is probably the controlling factor, we estimate that the total market for aluminum castings should increase 50% in the next five years. Since, for many reasons, the sand casting activity is expected to remain relatively static, the growth is anticipated to take place almost entirely in the permanent mold and die casting processes."

Again this heavy emphasis is on growth in the casting processes which best lend themselves to mechanization, automation and precision.

In a recent MODERN CASTINGS

10 Year Growth of Aluminum Castings

	1949	1959	1965 (estimated)
Shipments of Sand Castings (in pounds)	106,825,000	141,987,000	140,000,000
Shipments of Permanent Mold Castings	102,908,000	274,855,000	610,000,000
Shipments of Die Castings	88,019,000	368,101,000	1,075,000,000
Total	297,752,000	784,943,000	1,825,000,000

article, R. F. Thomson, Research Laboratories, GMC, predicted a glowing and growing future for cast aluminum in future automobiles. The potential uses and weights involved for each car are:

Part	Aluminum per Car (pounds)
Pistons	11
Transmission Parts	22
Cylinder Blocks	50
Cylinder Heads	40
Brake Drums	18
Clutch Housings	7
Intake Manifolds	9
	157

When you multiply these weights per car by 6 million cars (a good year's production) you are looking at 1 billion pounds of aluminum casting business!

Confidence in growth is being reflected in expansion of primary and secondary aluminum smelter capacity. This trend is world wide and on both sides of the "Iron Curtain". Also, with the raw material for aluminum (bauxite) one of the most plentiful ores on the face of the earth, with adequate smelter capacity, and with more uses in greater quantities it stands to reason that the cost of aluminum castings should decrease making them even more competitive.

Aggressive searching-out of new applications for aluminum castings accounts for much of the aluminum industry's past, present, and future success. This progressive attitude was in evidence as early as 1916. Peter S. Hardy reminisces: "The first company in the East that showed any interest in using aluminum castings, was the Mack Truck Co. During World War I, they indicated a willingness to make certain aluminum parts for their trucks where strength was not a prerequisite. The Pierce-Arrow Co. was another firm with courage to give aluminum a test. We cast their fenders of 1/4-inch thick aluminum".

"For a long time aluminum was not acceptable for use in the manufacture of cooking utensils. Many people felt that it would be injurious to cook food in aluminum pots or pans. Articles were written cautioning people not to use aluminum cookware. It took a very aggressve selling campaign to induce the stores to put aluminum utensils on their shelves and allay their fear of suit from supposed illnesses arising out of the use of aluminumware".

Today aluminum castings comprise important components in automobiles, outboard motors, industrial engines, compressors, machine tools, chain saws, lawn mowers, railroad cars, highway and bridge construction, buildings, electrical and electronic devices, trucks, tractors, aerospace industries, radar, washing machines, bowling alley equipment, street lights, marine equipment, power tools, business machines, and many others. It is this diversification of markets that has provided the strength in depth so requisite to a growth industry.

A partial list of specific individual aluminum castings now in use or proposed would include:

- transmission housings
- fittings
- wheels
- brake drums
- building spandrels
- door hinges
- steering column shrouds
- instrument panels
- blowers
- wheel discs
- distributor bases
- oil filter housings
- water pump pulley hub spacers
- fan spacers
- generator end plates
- engine blocks
- cylinder heads
- carburetor parts
- power brake components
- pistons
- rocker arm shaft supports
- valve rocker arm supports
- bearings
- starter end plates
- power steering housings
- master cylinder pistons
- air conditioning units
- wheel cylinder pistons.

Last month's issue of MODERN CASTINGS (December, 1960, page 42) carried a story about a new use for cast aluminum—spandrels for forming the exterior of skyscrapers. In the past year the first bi-metallic automobile wheel—an aluminum wheel cast around a gray iron liner—has reached the production stage. It's been estimated that this one item could grow into a 400 million pound a year market!

Much of the growing popularity of aluminum can be attributed to the increasing awareness of the economies inherent to weight-saving. Dead weight is an extrava-

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gance in any device that moves. The initial higher cost of a light weight casting on a vehicle can often be justified by calculating the savings in fuel and the increased pay-load. Not to be overlooked is the corrosion resistance offered by aluminum in many environments fatal to other metals.

Technical Assistance

Rapid growth has placed a heavy strain on aluminum foundrymen to keep production capabilities in tune with demands. New technology has been required to keep pace with quality requirements of discerning buyers. In reply to our question, "What technological advances are helping foundry operations most?", our panel of experts replied:

1. The development of new alloys, especially the high purity types, have pushed back the tensile and temperature barriers.

2. American Foundrymen's Society sponsored research in the fields of fluid flow, gating, risering, chilling, heat transfer, and metallurgy have advanced metalcasting know-how.

3. Air Material Command sponsored research has aided static and centrifugal permanent mold casting.

4. Improved melting practices through use of electric furnace melting now produce better quality at lower cost.

5. Hypereutectic silicon aluminum alloys have been developed for use where weight, wear resistance, and coefficient of thermal expansion are factors.

6. Improved mold and core making by the shell and CO_2 systems permit more economical casting to closer dimensional tolerances.

7. Die casting has benefited from development of larger more versatile machines, improved injection equipment, labor saving devices such as metal pumps and lubricators, automatic ladling, die evacuation, and use of sonics and ultrasonics to influence solidification.

8. The bi-metallic interlock for bonding cast iron inserts and transplant coatings are most important for aluminum engine cylinder components.

9. Key technical advances in permanent mold casting include use of pressure feeding, quick curing and collapsing core sand formulations, and improved metal preparation techniques.

10. Development of vacuum testing apparatus provides a control for producing molten aluminum substantially free of oxides and gas.

11. Oxide coating of dies now permits casting of low iron, high shock-resistant alloys.

12. Sound leak-proof die castings can be made by providing generous gates and low injection pressures to prevent metal "squirting" into die; this action is followed with high pressure for quick solidification of heavy sections.

Not to be overlooked is the innovation of building "hot metal foundries" adjacent to primary smelters so molten metal can be delivered directly from producer to consumer, thereby eliminating a pigging and remelting operation.

The alert aluminum industry has no intentions of being complacent with its success. They are looking around constantly for new product worlds to conquer and new ways to improve their ability to compete.

Success in this approach is being demonstrated by those foundries which can cast such new alloys as B 356, A 360, and 220. These castings demonstrate high shock resistance and long life in rough service. And they are encroaching on fields long dominated by various other cast metals.

A constant search for new and improved methods and techniques is mandatory. This embraces labor-saving and automated equipment, casting methods which require less or cheaper materials, lower tooling costs, and the broad development of processes which may be ineligible today because of size, complexity or economics.—F. C. Irving, Jr.

Reliability must be built into every casting in every operation performed on it. To maintain control of every process today's aluminum foundries must be supervised by trained technical personnel capable of providing metallurgical and engineering control. The customer's first demand is for quality castings. You can compromise on price but not on quality.

A need for closer liaison with the customer means sales engineers must be capable of working with design engineers and casting buyers. To properly service accounts the sales engineer needs a broad understanding of metallurgy, foundry practices, patternmaking, engineering drawing, and mechanical design.

Probably the greatest single effort on the part of buyers today is in the area of quality control. In order to compete with other methods, whether aluminum or otherwise, the foundry industry must develop better castings.—L. A. Pankratz

The knowledge of trained personnel is becoming obsolete as fast as yesterday's equipment. To stay abreast of today's rapidly changing technology foundrymen must read the current literature, attend meetings, and go back to school for special courses.

Aluminum foundrymen are waging a competitive battle on many fronts: the jobbing foundry vs. the captive . . . sand casting vs. permanent mold vs. die casting . . . aluminum vs. iron, steel, magnesium, zinc, brass, bronze and plastics . . . metalcasting vs. forging, extruding, stamping, and rolling. But competition won't go away by ignoring it. Improve your competitive posture by applying the new technology for profit.

Circle No. 149, Pages 141-142

"P-L-E-A-S-E, Dear Koppers..."

That guy Satan is a persistent devil all right. He's called a dozen times begging to buy some of our Koppers Premium Foundry Coke. It's kinda hard to keep saying no, because *he* says business is good down there and he wants to place a big order.

But business is good up here, too. Apparently the word has been getting around that Koppers Foundry Coke keeps operating costs way down and maintains a higher temperature range.

The reasons are these: Koppers Coke is prepared from the best quality West Virginia coals, carefully blended and baked the right length of time. It's absolutely uniform in *size, strength, structure* and *chemical analysis.* We check each day's run to be sure.

And because of its superior physical qualities, high carbon and low ash, Koppers Coke enables foundrymen to maintain higher temperatures which increases the cleanliness of the iron and helps to reduce fuel consumption.

No, we're still not going to sell Brother Satan—but we'd sure like to sell you. Why not make your next order Koppers Premium Foundry Coke? Available anywhere in the U.S. or Canada, it's sized to fit your needs. Koppers Company, Inc., Pittsburgh, Pennsylvania.

Koppers Premium Foundry Coke

S. C. Massari

Castings Congress Papers

Present concepts of foundry sand technology are questioned in two Castings Congress papers this month. Others deal with centrifugal casting of aluminum-uranium alloys, more efficient use of bottom boards, soundness in long and short term freezing alloys, superheating in roll-type cast iron, malleable graphitization, and metal-mold reactions.

TECHNICAL HIGHLIGHTS

Centrifugally Casting Aluminum-Uranium Alloy.p 53
Centrifugal casting techniques are adaptable to the production of acceptable hollow aluminum-35 w/o uranium extrusion billets for reaction fuel. The inherent economies of multiple-length castings, permanent molds, and high yields associated with centrifugal castings are realized without sacrificing casting quality. Segregation and porosity, serious problems in static casting, were eliminated by centrifugal casting.

Granular Movement During Squeezing .....p 60
In using rectangularly shaped squeeze boards, no granular movement is to be expected in a direction parallel to the longer dimension of the board. Better squeeze compaction will be accomplished if the dimensions of the boards are reduced to take advantage of the greater movement of sand within the zones of radial shear.

Soundness in Alloys .....p 63
Short freezing range alloys indicate a strong dependence on feed metal requirements on mold material, casting shape, section thickness, and solidification temperature. Long range freezing alloys can be made to feed better by applying pressure on riser or self pressurizing from risers with a plug of gas-producing hexachlorethane.

Chilling Roll-Type Cast Iron .....p 75
An increase in superheating temperature from 2600 F. to 2900 F. increases the chill capacity of melts poured at 2450 F. A decrease in pouring temperature from these superheating temperatures reduces chill depth. Differences in melting stock have a marked effect on the chilling behavior of melts heated to 2600 F., but had less influence on those superheated to 2900 F. The superheating temperature does not markedly affect the structure of the white iron and gray iron portions of the chill test castings. Lowering the pouring temperature to 2450 F. produces noticeable changes in the white iron structure.

Sand Design and Control .....p 85
Data indicates that almost any combination of physical properties can be obtained through a variation in clay and water content and mulling efficiency. The tremendous variation in physical properties possible through mulling alone helps explain why sand formulations successful in one foundry are unsatisfactory in another.

Malleable Graphitization Kinetics .....p 93
The effects of traces of Bi, Sb, Sn, Pb, Cd and Zn were studied. Some trace elements react with sulfur in irons with low Mn-S ratios and others do not. These elements do not form sulfides in irons with high Mn-S ratios. In such irons the trace elements are all mildly retarding to graphitization rates.

Factors Affecting Metal-Mold Reactions .....p 104
A practical means of minimizing interface reactions may be possible through use of organic sand binders which control the interface atmosphere. In the studies, the atmosphere produced by phenolic resin bonded shell molds resulted in slight reaction and reaction products typical of a less oxidizing atmosphere than green sand molds. Manganese additions caused extensive silicate melt formation. The reaction became more pronounced with increasing manganese content in green sand molds.

Sand Clay Bonding .....p 111
Many theories regarding foundry sand technology are merely assumptions. Questioned are clay film thickness and clay distribution by mulling. Investigations were made through micrographic studies on steel foundry sands but the findings undoubtedly may be extended to other fields.

The technical articles appearing in this preview section of MODERN CASTINGS are the official 1961 Castings Congress Papers. Nearly 100 technical papers are scheduled for presentation at the 65th Castings Congress to be held May 8-12 in San Francisco. Readers planning to participate in oral discussion of these papers during the Castings Congress are advised to bring them to the technical sessions for ready reference. Written discussion of these papers is welcomed and will be included in the 1961 AFS TRANSACTIONS. Discussions should be submitted to the Technical Department, American Foundrymen's Society, Golf and Wolf Roads, Des Plaines, Ill.

ALUMINUM-URANIUM ALLOY CENTRIFUGAL CASTING

by N. E. Daniel, E. L. Foster and R. F. Dickerson

ABSTRACT

Centrifugal casting techniques were investigated as a method of producing hollow cylindrical extrusion billets of aluminum-35 w/o uranium. Among the variables evaluated were melt temperature, mold and pouring spout configuration, mold speed and method of pouring. With the equipment employed, it was found that the best castings were produced using a pouring temperature of 2400 F, a heavy-walled steel cylinder rotating between 700 and 900 rpm for the mold and a bottom pouring technique employing a retractable pouring spout.

Sound, nonporous billets 26 in. long and 5 in. in diameter were produced with a yield after machining of over 75 per cent of the original charge. The major losses occurred in the pouring spout and cup assembly. This loss is relatively unaffected by the casting length, and, therefore, castings of greater length than 26 in. should result in even greater recoveries.

INTRODUCTION

The most commonly used alloy fuel for low temperature water cooled water moderated reactors are those of the aluminum-uranium alloy system. One method of fuel element fabrication currently employed involves coextrusion of aluminum-uranium alloys and pure aluminum to form tubular elements clad inside and out with aluminum.[1,2] For this process a tubular casting is desirable. However, when alloys containing more than 20 w/o uranium are lip poured in static molds, porosity and segregation are encountered.

The porosity is attributed to shrinkage and to gas evolved during freezing. The segregation is due primarily to differences in the densities of the various phases present, and to the widely separated liquidus-solidus temperatures.[1,3-5] Figure 1 shows the phase diagram of the aluminum-uranium system with a table of density of the various phases.

Since horizontal centrifugal casting has been established as a method of obtaining dense castings, and has found acceptance in such diverse casting applications as the production of cast iron pipe and high integrity steel gun barrels,[6] and since the castings desired were essentially pipes of unusually high integrity, this technique appeared particularly attractive as a method of casting aluminum-uranium extrusion billets. In addition to improving the ingot soundness, horizontal centrifugal casting should eliminate end-to-end gravity segregation.

Permanent molds could be used, and the casting surfaces should require a minimum of machining prior to extrusion. No gating or riser scrap should be generated. Of equal importance to the above advantage is the fact that the process is adaptable to the production of long tubes. Thus, it was considered possible that the process would be amenable to the pro-

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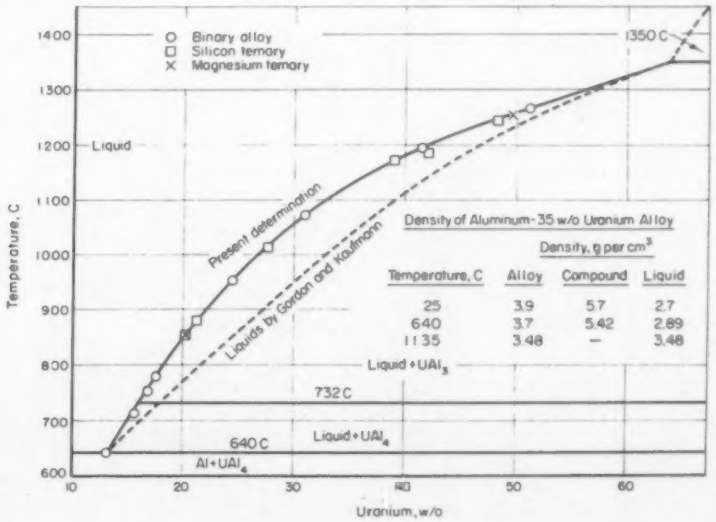

Fig. 1 — Partial aluminum-uranium constitutional diagram.

Fig. 2 — Machined interior surface of an aluminum-35 w/o uranium 10 in. long extrusion billet exhibiting center shrinkage band.

duction of multiple-length extrusion billets. The production of multiple-length billets and the reductions in scrap generation and in fabrication cost could offer a distinct economic advantage.

The ultimate objective of the study was to determine the feasibility of producing multiple-length extrusion billets. However, because of the numerous variables encountered in centrifugal casting it was desirable to conduct the investigation in two phases. The first phase was concerned with the application of the technique to the production of single-length billets, and the second phase was concerned with the production of multiple-length billets.

PREPARATION OF SINGLE-LENGTH CASTINGS

Experimental Procedure and Equipment

During the initial investigations, which were designed to obtain a more complete understanding of the problems that would be encountered in casting these particular alloys, single-length extrusion billets of the aluminum-25 w/o uranium alloy were prepared. The alloys were melted in either graphite or zirconia crucibles with the molten alloy being degassed by bubbling helium through it. The mold was made of tubular steel approximately 5 in. in I.D. with a wall thickness of ¼-in.

The back or closed end of the mold was sealed with a ½-in. steel plate attached to a turntable which was rotated at 550 rpm. The forward or charging end of the mold was closed with a one in. thick graphite plate having a 2 in. diameter hole for teeming. Through this hole a graphite pouring spout was inserted into the mold. The position of the pouring spout in relation to the forward end of the mold was changed with each succeeding melt.

Visual examination of the billets after sectioning revealed that the castings were essentially sound and had good exterior surfaces. The only evidence of porosity was noted in a band approximately one in. wide located about midway from the ends of the castings. The appearance of this band and its location, as shown in Fig. 2, indicated that the porosity was caused primarily by shrinkage.

In the next experiments, melts of both 25 and 35 w/o uranium were poured into a steel mold with a tapered wall. This mold, 10 in. in length with an I.D. of approximately 5 in., was mounted so that the rear of the mold, consisting of a ½-in. thick section, was in contact with the turntable. The front or charge end of the mold had a wall thickness of ⅛-in., and extended without support from the turntable. It was thought that such a design would impart directional cooling and displace the porous zone to the extreme front end of the casting. There it would be removed by cropping.

Since the effect of mold speed had not been established, castings were made using speeds up to 1200 rpm. The pouring temperatures investigated were 2100, 2200 and 2300 F for the 25 w/o uranium alloy, and 2300, 2400 and 2500 F for the 35 w/o uranium alloy. As expected, the increased cooling rate obtained at the rear of the castings displaced the porous shrinkage area toward the front of the mold;

however, the extent of this displacement was not as great as expected. Visual examination of these castings revealed that mold speeds of 700 to 1200 rpm yields the best interior surfaces.

The casting poured into the mold rotating at 1200 rpm exhibited exterior surface imperfections which appeared to be hot tears that had subsequently refilled with molten alloy. In castings poured at 2300 and 2400 F into the mold rotating at 700 or 900 rpm and heated to 400 or 500 F at the front end, it was possible to obtain ingots containing sound material for 75 per cent of their length.

In an effort to improve the quality of the castings in both casting integrity and homogeneity, various types of pouring spouts were investigated. These investigations showed that the best quality castings were obtained when a spout having only one large hole, which introduced the metal normal to the horizontal axis of the mold, was employed. This permitted the introduction of the metal at the exact location at which it was desired.

Evaluation of Melts and Techniques

In most cases the as-cast shapes were evaluated by radiography and by macro- and micro-examination. In certain cases these tests were supplemented by chemical analyses. The aluminum-35 w/o uranium castings poured into steel molds were evaluated in detail. Examination of the surfaces revealed that acceptable inside surfaces were obtained at mold speeds of 700 and 900 rpm. All of the 35 w/o uranium castings poured at 2400 F, and with mold speeds of 550 to 900 rpm, exhibited good exterior surfaces that required little or no machining. Figure 3 shows an ingot cast into the tapered steel mold. It can be seen that the inside surface of the ingot is good.

Approximately three-fifths the distance from this end (the back end of the mold) there is a beginning of the roughness and porosity noted in these ingots. The band of extreme porosity noted in the earlier ingots is located about three-fourths of the distance from the back end of the castings. Radiographic examination of sections cut from the ingots revealed areas of high uranium concentration present in those sections of the ingots where the molten metal was introduced. The variation in uranium content in a number of castings was ± 5 to 8 w/o from the nominal 35 w/o, with the lowest uranium concentrations occurring in the areas of the castings furthest removed from the pouring point.

Conclusions from the First Phase

From the experiments it was observed that the following conditions were necessary for the production of satisfactory castings:

1. A mold speed at or near 700 rpm on a mold 5 in. in diameter. Since the effects of increasing the rotational speed of the mold is to increase the centrifugal force exerted in the molten metal, and thus increase the tendency toward radial segregation, it is desirable to use the slowest speed compatible with good interior surfaces.
2. A melt temperature of approximately 2400 F is optimum for the 35 w/o uranium alloys when centrifugal casting. This relatively high temperature is necessary to insure that the melt remain at least partly fluid until the entire mold cavity is filled.
3. A method of depositing the metal uniformly along the length of the mold is required. This elimi-

Fig. 3 — 10 in. long aluminum-35 w/o uranium ingot cast into tapered steel mold. Note surface imperfections and porosity in far end of casting. 1 ×.

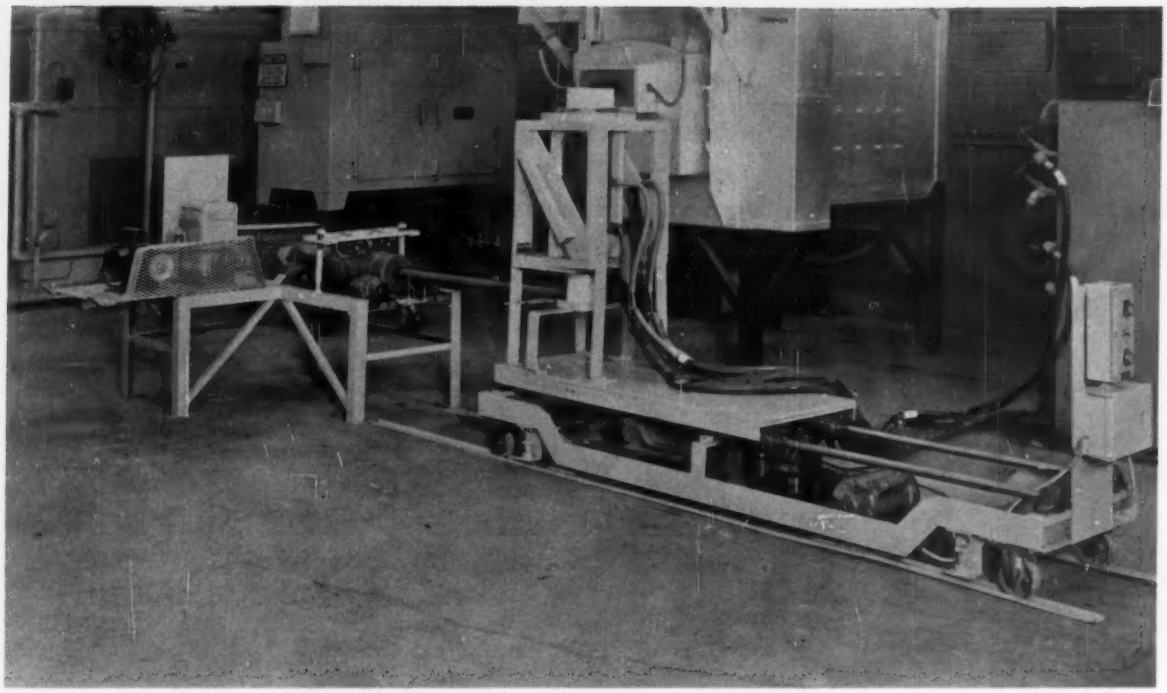

Fig. 4 — Centrifugal casting apparatus and retractable pouring spout assembly. The coil and crucible are in place for bottom pouring.

nates or appreciably lessens the end-to-end segregation. Areas of high uranium concentration are produced where the molten metal impinges upon the mold or upon previously solidified metal.

PREPARATION OF MULTIPLE-LENGTH CASTINGS

Experimental Procedures and Equipment

Upon completion of the first phase of the program in which single-length extrusion billets were prepared, emphasis was placed upon the production of aluminum-35 w/o uranium castings of sufficient length to yield two or more extrusion blanks up to 8.6 in. in length with an O.D. of 4.8 in. Mold speeds of 700 to 800 rpm and pouring temperatures of 2300 and 2400 F were used as the basis for the production of multiple-length castings. Further studies of spout configurations were required since the spout was to be moved along the axis of the mold as the metal was poured, whereas previously it had remained stationary.

The mechanism designed to produce movement of the spout is shown in Fig. 4. As shown in Fig. 4, the crucible and induction heating assembly was mounted on a movable platform which rested upon two one in. diameter steel rods which served as ways. The pouring cup and spout were also mounted on the movable platform. In Fig. 4, the cup and spout are in position for bottom pouring, a technique selected for use on the final sizes of the program.

Beneath the platform there was a reversible electric motor connected by a sprocket and chain to a speed reducer, which in turn was connected by a chain and sprocket assembly to the sprocket cluster shown directly beneath the right end of the movable platform. A continuous chain drive connected the sprocket cluster to a single sprocket mounted at the left or forward end of the platform. Contact with the movable platform was obtained by an extended link which engaged an extension welded onto the bottom of the platform. The chain drive permitted essentially slip-free operation, and by changing a sprocket in the sprocket cluster many spout withdrawal speeds were obtainable.

The electrical controls consisted of a three-station push-button control box and two limit switches. These permitted either automatic or manual control when it was desired to change the direction of travel of the pouring platform. The various speeds available, the ability to start, stop and to change the direction of travel when and where desired, made this a sufficiently versatile piece of equipment for the investigation of pouring techniques for centrifugal casting.

Preparation of Castings

Since the centrifugal casting apparatus used to produce the single-length extrusion billets introduced eccentricities in the ingots when molds of 18 and 26 in. in length were used, it was necessary to design an apparatus in which the mold would be supported upon a roller bed. This apparatus is shown in Fig. 4. It consisted of a steel mold supported by 2 in. wide by 4 in. in diameter wheels mounted on an angle iron frame. The mold was driven by an electric motor through a speed selector connected by a belt drive to a shaft mounted in the back end of the mold.

During the casting of the initial 26 in. long billets

using this device the melts were lip poured. An evaluation of the ingots so produced revealed extensive porosity beneath the interior surfaces of the casting extending to a depth of approximately 50 per cent of the wall thickness. This porosity was attributed to the uneven feeding of the mold as a result of the variable pouring rate. Shrinkage was also noted, and manifested itself as linear depressions in the interior surface of the cast shapes.

These results indicated the need for a pouring rate that would deposit the proper amount of molten metal at or near the position in the mold where it was to solidify. It was thought that this could most easily be obtained by pouring through an orifice. It was also thought that less gas pickup would be encountered by bottom pouring.

A bottom pouring induction coil and melting crucible assembly was mounted in the movable platform. The use of bottom pouring permitted the operator to obtain the desired constant metal flow into the pouring cup by using a break-off plug with the required orifice. It also decreased the exposure of the molten metal to the atmosphere. Figure 4 shows the bottom pour coil-crucible assembly and the mold assembly used in these studies. The melting and pouring techniques finally developed for 26 in. long billets were:

1. The aluminum was melted to 1800 F.
2. Uranium was added intermittently over a period of 10 to 20 min.
3. The melt was stirred while adding uranium, and stirring was continued until the uranium was in solution.
4. Melt temperature was increased to 2400 F.
5. The graphite pouring cup and spout assembly preheated in an electric furnace to 1400 F was placed in position beneath the coil.
6. The coil and pouring mechanism was rolled forward to pouring position.
7. The melt was stirred vigorously and bottom poured into the mold rotating at 850 rpm.
8. At approximately the instant that the metal began filling the mold, the retraction mechanism of the pouring assembly was started.

It should be noted that this melting cycle differs from that often used in casting aluminum-uranium alloys in that no outgassing techniques were employed, and the melt was not skimmed prior to pouring. The improved protection from atmospheric contamination afforded the metal during pouring, and the easy path for gas removal through still molten metal, are responsible for eliminating the need for outgassing.

A charge of 15 kg of metal was employed in casting the 26 in. long billets. It has been determined that approximately 19 sec is required to pour a melt; therefore, the rate of retraction of the pouring spout was 26 in. in 19 sec. From surface temperature measurements it was determined that the pouring cup and spout temperatures were approximately 900 F at the time of pour.

Evaluation of Multiple-Length Castings

Since one of the primary reasons for investigating centrifugal casting as a technique for the production of cylindrical extrusion billets was to determine if substantial savings could be affected in the amount of material that must be recycled or otherwise reclaimed, a material balance was obtained on all of the ingots produced by this technique. This material balance included the weights of all materials used in the charge and all losses during melting and casting. Also included in the original material balances were the weights of all materials removed from the ingots during machining and for chemical and radiographic analyses. For brevity, and to make the material balance more meaningful, the average material balance for 5 in. O.D. by 26 in. long extrusion billets is given in Table 1.

TABLE 1 — MATERIAL BALANCE IN KILOGRAMS

Charge wt.	15.00
Material left in crucible and pouring cup and spout	1.60
Casting wt.	13.40
Wt. of material removed from ends and surface	1.20
Total wt. of machined castings	12.20

The 26 in. long ingots were evaluated by various techniques—principally visual inspection, radiographic examination and chemical analyses. The visual inspection revealed extremely good exterior surfaces on all melts, including one 25 w/o uranium ingot. This ingot is shown in Fig. 5. In Fig. 6 are two aluminum-35 w/o uranium castings exhibiting the same fine surface. The interior surface of an aluminum-35 w/o uranium casting is shown in Fig. 7. Castings of this type required the removal of only approximately $\frac{1}{16}$-in. of material from the radius of the inside surface to obtain completely sound material. Radiographic examination of sections cut from the ingots revealed areas of low uranium concentration around the interior surface of all castings. Figure 8 shows, typical radiographs of ring sections. Although the areas depleted in uranium vary in thickness from end to end in the castings, chemical analyses of the heat castings made varied only from 32.1 w/o uranium to 35.3 w/o uranium. The $\frac{1}{4}$-in. wide bands which transverse the radiographed sections represent gaps where material was removed from chemical analyses. Some of the chemical analyses obtained are shown in Table 2, and indicate the range of uranium concentrations that were detected. These analyses show that the material removed from the inside surface during machining to produce a sound and uniform surface was extremely low in uranium containing 14.5 to 16.8 w/o.

An examination of the material balance shows that the greatest loss was due to material left in the pouring train and crucible. The material left in the crucible was almost negligible, and certainly no more than that which would have been removed from the melt if it had been skimmed. The major portion of this 1.60 kg was left in the pouring cup and spout. This material was massive and suitable for recharging.

It is believed that the results obtained during this investigation show that centrifugal casting techniques

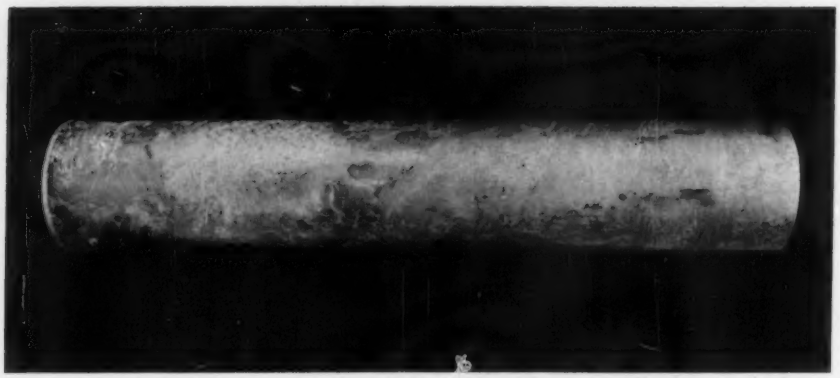

Fig. 5 — Exterior surface on a 26 in. long aluminum-25 w/o uranium extrusion billet. The surface finish is superior to that generally obtained by static casting techniques.

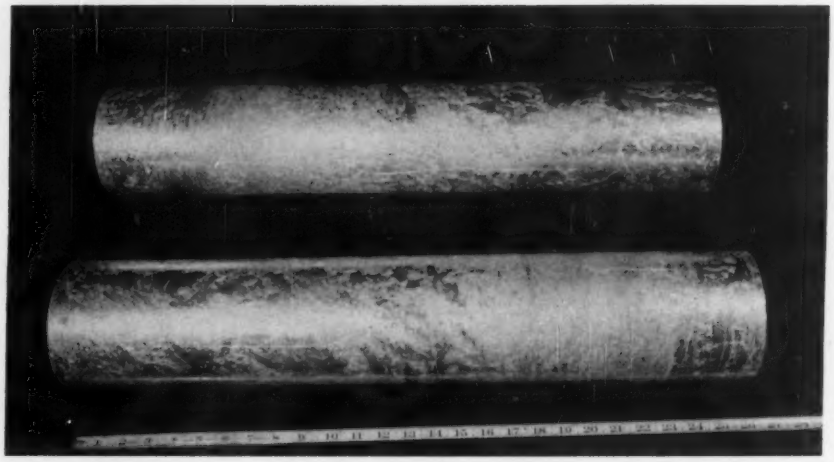

Fig. 6 — Exterior surfaces of two 26 in. long aluminum-35 w/o uranium extrusion billets. The fine surface finish was typical of that obtained on multiple-length 35 w/o uranium castings toward the end of the program.

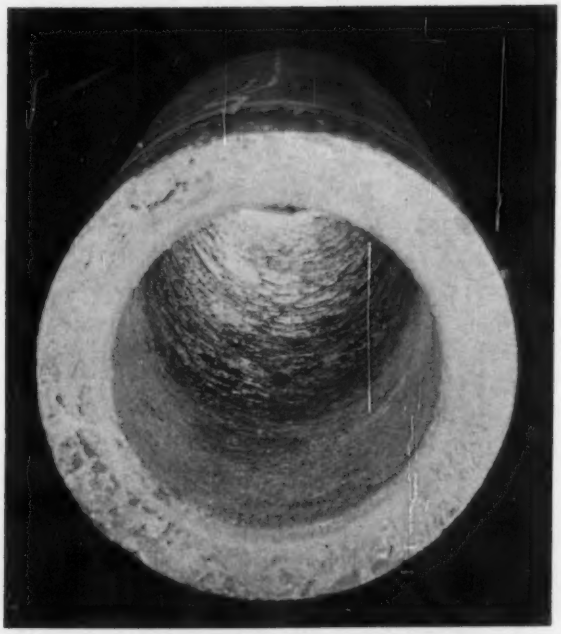

Fig. 7 — Interior surface of 26 in. long aluminum-35 w/o uranium extrusion billet. Only minimum machining was necessary to produce a satisfactory interior surface.

TABLE 2 — CHEMICAL ANALYSES OF 26 IN. LONG ALUMINUM-35 w/o URANIUM BILLETS

Ingot	Sample Location	Analyses Composition, w/o
9	Front	34.7
	Middle	33.8
	Inside Surface	16.8
12	Front	32.1
	Middle	35.3
	Rear	32.6
	Inside Surface	15.5
13	Front	32.0
	Middle	33.0
	Rear	37.3
	Inside Surface	14.5

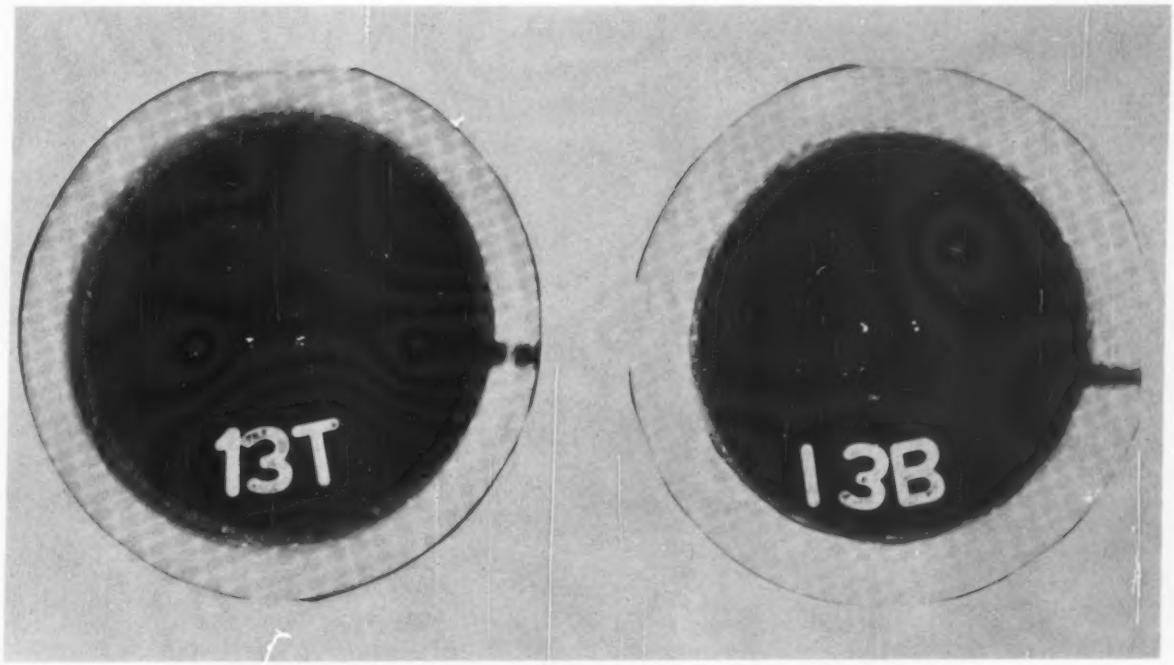

Fig. 8 — X-ray of front and rear sections of aluminum-35 w/o uranium extrusion billet. Some migration of the uranium toward the major diameter is apparent. The gaps in the edges were produced by sampling of chemical analysis.

are adaptable to the production of acceptable aluminum-uranium extrusion billets. Furthermore, the inherent economics of multiple-length castings, permanent molds and high yields that are associated with centrifugal casting are realized without sacrificing casting quality. Refinements in the pouring techniques and equipment might result in even better recoveries than those obtained during this study.

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GRANULAR MOVEMENT DURING SQUEEZING

by D. C. Williams

ABSTRACT

Density of the sand adjacent to a squeeze board is greater than that found at the parting line of a flask. The author attempts to explain this using material from the discipline of soil mechanics. Granular movement during squeeze molding operations is divided between a movement toward a horizontal direction and a movement toward a vertical direction. The author suggests that better squeeze compaction would be accomplished if squeeze boards were decreased in size to take advantage of greater sand movement.

INTRODUCTION

The compaction of sand mixtures by the squeeze method has always been marked by the relatively short distance the rigid squeeze board would descend inside the perimeter of the flask. It is also well known that the density of the sand immediately adjacent to the squeeze board is considerably greater than that found at the parting line. This has usually been considered as the "nature" of squeezing, and so it is. This paper will make an attempt to explain this nature using material from the discipline of soil mechanics as provided by Terzaghi.[1]

SQUEEZE BOARD DATA

Figure 1 is a reproduction of Terzaghi's[1] Fig. 15a. Let the superimposed load $q'c$ be equivalent to the weight of the squeeze board, and the load $q''c$ be equivalent to the load applied to the squeeze board. Point a will indicate the side of a square or round squeeze board or the long side of a rectangular squeeze board.

Through point a there are two lines, aD_A and aD_p, which divide the mass of sand mixture into three zones, namely:

1) The active Rankine state wherein the sand mass is expanding in a horizontal direction.
2) Zone of radial shear.
3) The passive Rankine state wherein the sand mass is contracting in a horizontal direction.

It is important to note that above the line aD_A, and to the right under the squeeze board, the movement of the sand mass is along surfaces of sliding which descend from the surface at an angle $(45° + \phi/2)$. Also above the line aD_p and to the left above which there is no supercharge load, the sand mass will move along surfaces of sliding at an angle of $(45° - \phi/2)$. Note also that in the zone of radial shear the surfaces of sliding are logarithmic in shape, and connect the angles of the surfaces of sliding in the active and passive Rankine zones.

In general squeeze molding practice the squeeze board is so designed that it fits just inside the perimeter of the flask (straight or tapered sides). Under such conditions one can consider that the inside surface of the flask can be thought of as a vertical surface through point a. Therefore, during squeezing sand grain movement along the surfaces of sliding will involve only the active Rankine state and a portion of the zone of radial shear.

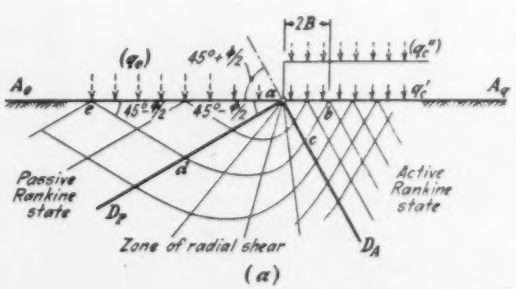

Fig. 1 — Movement of sand grains under one side of a square or long side of a rectangular squeeze board (Terzaghi[1]).

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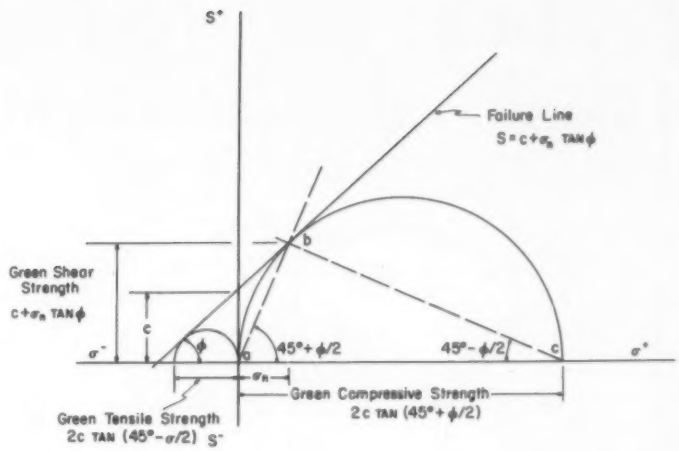

Fig. 2 — Graphical method to determine the surfaces of sliding (45° + Φ/2) and (45° — Φ/2) when sand testing produces values for green compressive and tensile strengths.

SAND RESISTANCE

For the squeeze board to descend into the flask it is necessary for failure along the logarithmic shaped surfaces of sliding toward a horizontal direction. Only as the sand mixture moves outward to the vertical surface of the flask building up frictional resistance can the squeeze board descend. In this case then the descent of the squeeze board stops when the frictional forces against the flask become equal to the applied squeeze load.

It should be recalled that it is common practice to peen around the perimeter of the flask. However, this location is precisely that wherein the logarithmic surfaces of sliding take place which allows the squeeze board to descend. If peening has been done too near the top of the flask, this prior compaction in this zone will restrict the movement in the zone of radial shear thereby limiting the depth of squeezing.

In Fig. 1, it will be seen that the surfaces of sliding in the radial zone start from the line aD_A at an angle of $(45° + \phi/2)$ and continue to the left. This means that the initial downward direction of the logarithmic surfaces of sliding is steeper as the angle of internal friction ϕ increases. The determination of the angle ϕ and $(45° + \phi/2)$ and $(45° - \phi/2)$ are readily made if either of the combinations green compressive and tensile strengths or green compression and shear strengths are available.

MOHR'S CIRCLES

Figure 2 is a schematic representation of Mohr's circles of stress developed when the green compression and tensile strengths are available. Half circles whose radii are one half the values of the green compressive and tensile strengths are constructed, as shown about the σ and s axes. A line is drawn so that it is tangent to both half circles, and this line is known as the failure line. Where this line becomes tangent to the compression half circle, this location indicates the green shear strength of the sand mass. Constructing the lines ab and bc will provide the values for $(45° + \phi/2)$ and $(45° - \phi/2)$.

If the combination of test values for green compression and shear strengths are available, then by the representation in Fig. 3 the desired angles of the surfaces of sliding can be determined. Construct a half circle which represents the green compressive strength. Locate the shear strength value b on the half circle and draw the lines ab and bc by which

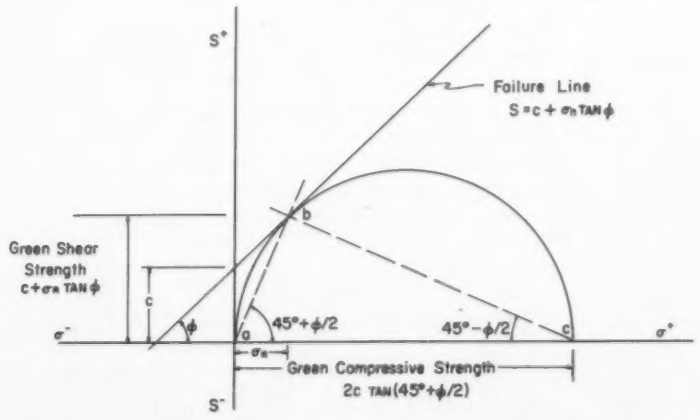

Fig. 3 — Graphical method to determine the surfaces of sliding (45° + Φ/2) and (45° — Φ/2) when sand testing produces values for green compressive and shear strengths.

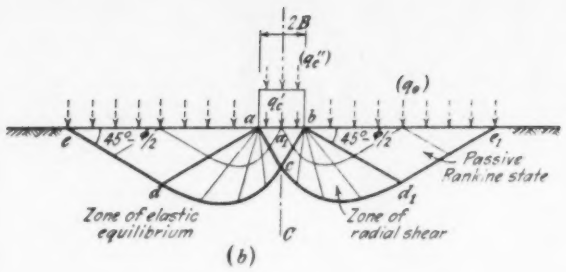

Fig. 4 — Movement of sand grains under a rectangularly shaped squeeze board (Terzaghi[1]).

the values for $(45° + ø/2)$ and $(45° - ø/2)$ are easily measured.

It would thus seem advisable that the dimensions of a square or round squeeze board should be changed from those that just fit inside the perimeter of the flask. Allowing a clearance of one in. or more between the squeeze board and the inside perimeter of the flask should permit increased horizontal movement of the sand grains in the radial shear zone before the frictional forces against the flask surface becomes equal to the applied load. Also, the squeeze pressure in psi will increase due to the smaller board area used. Consequently, the squeeze board will descend deeper into the flask tending to bring about a greater density toward the parting surface.

Figure 4 is a reproduction of Terzaghi's[1] Fig. 15b. Here will be seen the situation under a rectangularly shaped squeeze board. Note that points *a* and *b* indicate the sides of the squeeze board where the distance *ab* is the short dimension of the rectangular shape. For such a shape there are two zones of radial shear, two zones of the passive Rankine state and one zone *abc* directly under the squeeze board.

RADIAL SHEAR ZONE

In order for the squeeze board to descend into the flask the sand masses in the radial shear zone must move somewhat horizontally in opposite directions from the center line toward the inside surface of the flask. The usual practice of fitting a rectangular squeeze board to the inside perimeter of the flask means that only a small portion of the zone of radial shear is available to accommodate compaction. It is important to remember that for rectangular squeeze boards there is no movement of grains in the direction of the flask surface of the shorter dimensions. This fact should be considered when laying out patterns on the patten plate and when making a diagnosis of casting defects attributable to molding practice.

Thus, it will be seen that for rectangular flasks wherein the compaction is accomplished by squeezing, it is useless to consider the problem of flowability in a direction parallel to the long dimension of a rectangular squeeze board because there is no movement in that direction. In addition, to compact the sand across the short dimensions of a rectangular flask peening is necessary at such locations.

It seems probable that better squeezing can be accomplished with rectangular boards, if the width of the board was decreased by one in. or more on a side to allow more of a zone of radial shear to be available to produce a greater descent of the squeeze board.

A relationship between soil mechanics and the compaction of a sand mixture can be made if one likens the squeeze board to a footing. Then from Trask and Skjei[2] we find that "considerable data exist to show that the only dimension of a footing having a large effect on the bearing capacity of the soil is the breadth of the footing."

CONCLUSION

The information presented above shows that the movement of granular materials during the squeeze molding operation is divided between a movement toward a horizontal direction and a movement toward a vertical direction. For the squeeze board to descend the two movements occur simultaneously. Without a horizontal movement below the edges of the squeeze board there will be no descent of the board (or footing). A graphical method has been described which will provide the angles of the surfaces of sliding $(45° + ø/2$, active Rankine state) and $(45° - ø/2$, passive Rankine state).

For rectangularly shaped squeeze boards no granular movement is to be expected in a direction parallel to the longer dimension of the squeeze board. It is suggested that better squeeze compaction would be accomplished if the dimensions of the squeeze boards were reduced to take advantage of a greater movement of sand within the zones of radial shear. Since grain movement during squeezing is anisotropic, flowability studies must consider the geometry of the squeeze board (or footing).

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FACTORS AFFECTING SOUNDNESS IN ALLOYS WITH LONG AND SHORT FREEZING RANGE

by J. T. Berry and T. Watmough

ABSTRACT

After a brief discussion of major mold material and casting alloy variables upon the production of sound castings in pure metals, eutectic composition and long freezing range alloys, a specific study is made of two areas of topical interest. The two areas concerned are:

1) The extent of the influence of mold material upon the feeding requirements of three short freezing range alloys.
2) The effect of applied pressure to the feeder head of castings made in various long freezing range alloys.

In the first area, simple-shaped castings of various configurations have been cast into green sand, oil, sodium silicate and cement bonded sands. Alloys considered were 13 per cent Si-Al alloy (no. 13), gray cast iron of eutectic carbon equivalent and 0.2 per cent carbon steel. The important interrelated effects of mold rigidity, geometric restraint and section thickness upon under riser shrinkage have been rationalized.

In the second area, the extent of interdendritic shrinkage porosity in degassed, long freezing range aluminum alloys cast into 2 in. square and 4 in. square bars has been investigated.

The particular alloys concerned were aluminum alloys no. 43, 220 and 355. Pressures up to 20 psi were applied to the feeder heads of the castings, and the effects of this pressure on the interdendritic shrinkage were recorded.

INTRODUCTION

Riser dimensioning and positioning, as a means of procuring sound castings, has until recently been either a revered art or a matter of plain guesswork. The number of opinions on the solution of risering problems is probably only outnumbered by the number of publications on the subject. Any overall analysis of such publications would obviously be difficult as well as time consuming. However, it is generally acknowledged that application of the basic laws of heat and mass transfer, already limited by metallurgical variables, has been somewhat impeded by adherence to empirical information. It is the purpose of this paper to critically examine two particular aspects of casting soundness, namely:

1) The extent of the influence of mold material upon the feeding requirements of three short range feeding alloys.
2) The effect of applied pressure to the feeder head of castings made in three long freezing range aluminum alloys.

Although the first topic would appear initially to be connected with heat transfer alone, the families of variables shown in the tabulation are involved.

Family	Variable	Effect
Metal	Pouring temperature Metal or alloy type	Liquid contraction
	Solidification mechanism Metal or alloy type Gas content	Solidification contraction, or expansion
Mold	Interface temperature Moisture or volatile content Intergranular space Material Restraint	Mold contraction or expansion

The second topic, although appearing to be one of mass transfer alone, is also interconnected with the above variables. However, the dispersed type of unsoundness, known variously as microshrinkage, layer porosity, interdendritic shrinkage and centerline shrinkage, depends particularly on:

1) Intrinsic properties of the liquid metal
   a) Inherent viscosity.
   b) The surface tension existing between the liquid and solid phases.
   c) Range of Freezing.
2) Local thermal conditions
   a) Longitudinal temperature gradient.
   b) Lateral temperature gradient.
3) Pressure differential involving
   a) Metallostatic head.
   b) Applied pressure, if any.
   c) Mode of solidification of the alloy.

Before describing the design and results of the current experiments, it is pertinent that a brief examination be made of the present state of knowledge.

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TABLE 1 — TABLE OF K_g VALUES (CYLINDER-PLATE COMBINATIONS)

Filling Temp. of Mold C	Filling Temp. of Mold F	Mold Material	$K_g = (M_C/M_R)$
		Silumin Alloy	
700	1300	Dry sand, medium grain, medium rammed	1.17
700	1300	Green sand, medium grain, medium rammed	1.18
		Cast Iron	
1290	2350	Green or dry sand, coarse grain, hard rammed	1.18
1290	2350	Dry sand, fine grain, soft rammed	1.25
1200	2190	Green or dry sand, coarse grain, hard rammed	1.14
1200	2190	Dry sand, fine grain, soft rammed	1.20
		Low-Carbon Steel	
1585	2890	Green or dry sand, coarse grain, hard rammed	1.20
1585	2890	Diatomaceous earth and fine sand	1.35
1485	2700	Green or dry sand, coarse grain, hard rammed	1.16
1485	2700	Diatomaceous earth and fine sand	1.29

UNDER RISER SHRINKAGE PROBLEM IN SHORT FREEZING RANGE ALLOYS

Present State of Knowledge

The attack on the above problem has often left the practical foundry man in such confusion, that a critical evaluation of existing methods of dimensioning risers is required. Examination of previous work indicates that two basic methods have been employed:

a) Those based partly or wholly upon theoretical considerations, i.e., theoretical heat transfer methods.
b) Those based wholly upon empirical findings, i.e., measurement on actual castings to determine minimum riser sizes for particular castings.

It is the considered opinion of the writers that there has been insufficient integration of the two schools.

Referring to the fundamental rules as put forward some years ago by Chvorinov,[1] for risers and castings and relating total solidification time, t_s to volume-to-surface-area ratio V/A, the following difficulties are encountered:

a) General insensitivity of the original criterion:

$$\frac{V_R}{A_R} \geq \frac{V_C}{A_C}$$

where suffixes *R* and *C* represent riser and casting, respectively.

b) Neglect of the effect of differences in shape combination upon solidification times involved in riser-casting combinations.
c) Neglect of the many variables concerned in the expansion-contraction phenomena, within the metal or the mold.

Tentatively, to describe the deviation from a 1:1 ratio of V_R/A_R to V_C/A_C, intelligent application of two correction factors could be made. These factors could be designated as K_g (a geometric factor) and K_s (an expansion-contraction sensitive or shrinkage factor).

The mold geometry factor K_g can be predicted. This prediction involves the comparison of quantities known as the mold constant M for particular shapes. This constant is defined by the relationship

$$t_s = M\left(\frac{V}{A}\right)^2$$

K_g is thus, in turn, defined by the square root term in in the equation

$$\frac{V_R}{A_R} = \left[\sqrt{\frac{M_C}{M_R}}\right] \cdot \frac{V_C}{A_C}$$

Values of the square root term, i.e., K_g have been calculated using theoretical data from previous work.[2]

In Table 1 are exhibited typical values of K_g for cylinder-plate combination (The value of K_g for cylinder-sphere combinations is approximately unity).

It may be anticipated that by application of the tabulated K_g values to existing information[3,4] upon riser requirements, some data upon the extent of the K_s value may be determined. The experiments referred to [3,4] were designed to cover a range of shape combinations which deviate from the ideal cylinder-wide plate and cylinder-long bar combinations. Consequently, it is necessary to describe the casting shape in some way—for example, a degree of ranginess, i.e., maximum length divided by thickness.

Collected in Table 2 are observed critical ratios of V_R/A_R to V_C/A_C for the production of sound castings of varying "degree of ranginess." In addition, an apparent K_s factor has been extracted using an approximate K_g value, the above ratio and the equation:

$$\frac{V_R}{A_R} = K_s \cdot K_g \cdot \frac{V_C}{A_C}$$

It will be seen that the apparent K_s value varies with degree of ranginess.

It is suggested that the changing K_s values are to some extent dependent upon the variation of mold wall movement.[5] Quite obviously, certain mold cavity shapes—such as spheres, cubes and thick plates—should possess inherent rigidity characteristics which differ from those of wide plates and long cylinders. Consequently, further information upon the extent and interrelation of the effects of such variables as shape combination, mold cavity shape, mold material, section thickness and metal cast upon feeding requirements is required.

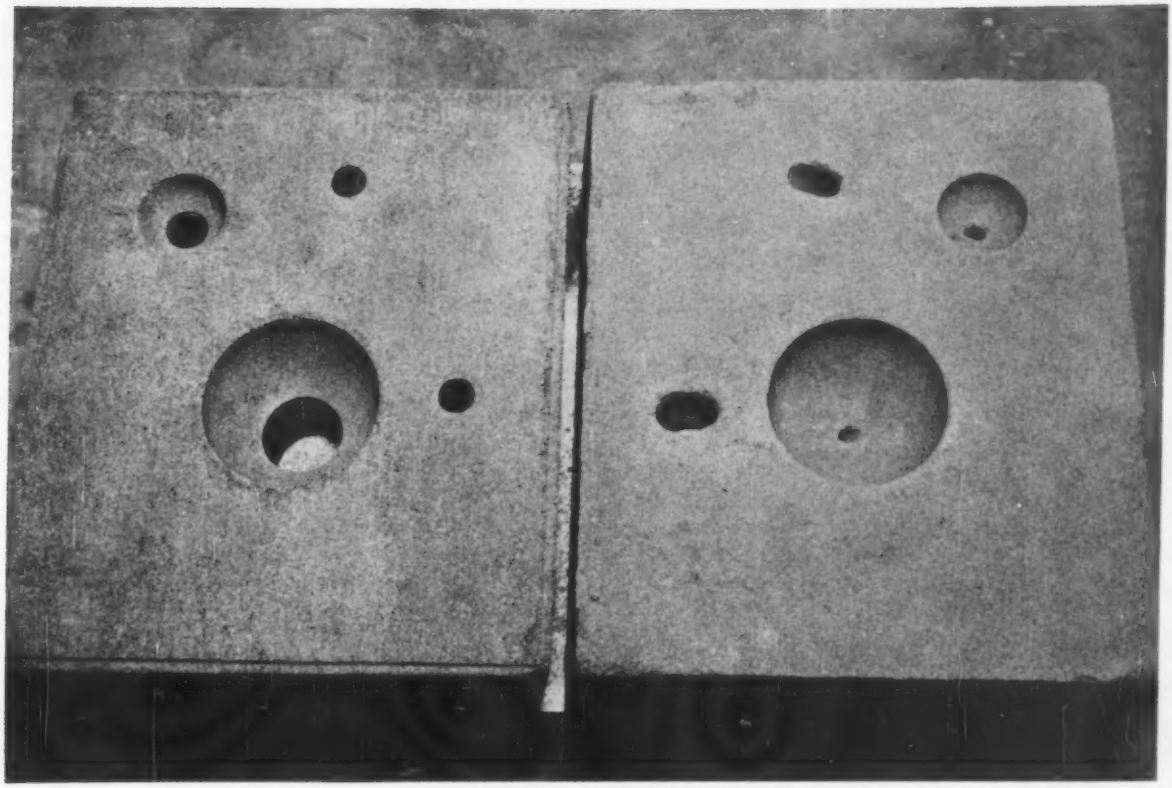


Fig. 1 — Mold for 2 in. and 4 in. diameter spheres.

Experimental Techniques

The experiments were initially confined to two commercial eutectic alloys, namely:

1) Aluminum-silicon alloy, no. 13 (13 per cent silicon).
2) Gray cast iron of eutectic carbon equivalent.

In addition, a small number of supplementary experiments were carried out utilizing a 0.2 per cent carbon steel.

Particular combinations of alloy, mold material, mold design and section thickness were covered. The mold materials concerned were:

1) Green sand.
2) Core sand.
3) Sodium silicate bonded sand.
4) Cement bonded sand.

The above represent an increasing order of rigidity. Details of the mold materials are given in Table 3.

Two casting designs were involved in the experiments, plate and sphere, both fed by cylindrical risers. The plate had major dimensions of 10 in. by 13 in. The section thicknesses concerned were 2 in. for the plates and 2 in. and 4 in. for the spheres.

Both shapes were bottom gated, the spheres being horn gated. Figure 1 shows a typical mold for a pair of spheres. The plate was made in the cope, and a horseshoe type gate was employed with the correct ingate-sprue ratio, to ensure even entry of metal into the mold cavity.

TABLE 2 — SHAPE COMBINATION EFFECT ON APPARENT K_s VALUES[4] FOR CYLINDRICAL RISERS

Casting Shape	Degree of Ranginess† (casting)	Observed Critical Ratio* of V_R/A_R to V_C/A_C	Calculated K_s‡	Apparent K_s
Plate	5	1.04	1.20	0.89
	6	1.10	1.20	0.92
	12	1.09	1.20	0.91
	18	1.33	1.20	1.11
Bar	2	1.01	1.20	0.84
	3	1.09	1.20	0.91
	7.5	1.10	1.20	0.92
	10.0	1.37	1.20	1.14

† Maximum length/thickness.
* Minimum for production of sound castings.
‡ Assuming no corner effects.

TABLE 3 — DETAILS OF MOLD MATERIALS

Components	Type of Sand			
	Green sand	Core sand	Sodium silicate bonded	Cement bonded
Wedron 5010 sand (W & D), lb	200	300	300	300
Western bentonite, lb	12	1		
Cereal binder, lb		4	4	
Core oil, qt.		2		
Kerosene, pt	1	1		
Sodium silicate, lb			36	
Cement, lb				30
Wood flour, lb	2			
Water, %	4			5
Mold treatment	None	Baked 400 F 12 hr	Baked 350 F, 12 hr	Air dried 5 days

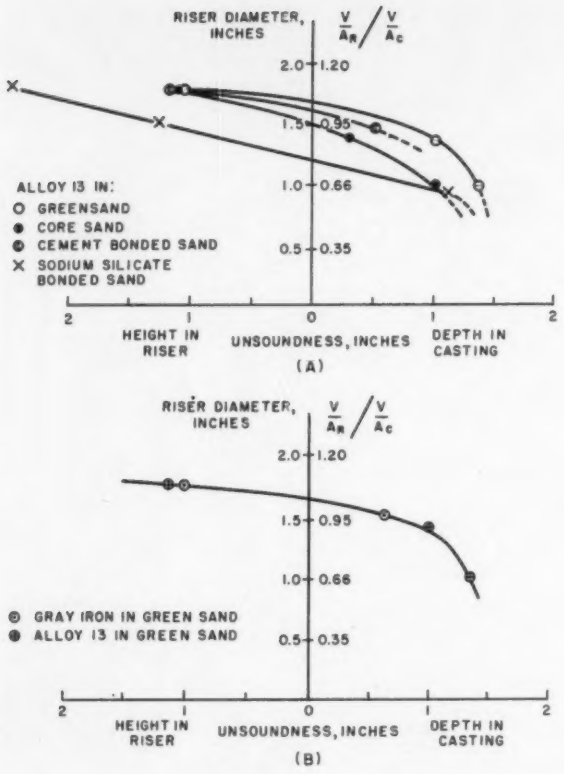


Fig. 2 — Shrinkage extent into castings made from aluminum alloy 13 and eutectic equivalent gray iron. The influence of various sand conditions on 2 in. diameter spheres is shown. All risers 4 in. high.

The metal was melted in a high frequency induction furnace under carefully controlled conditions.

The aluminum alloy was melted directly from high grade ingot stock. Vigorous chlorine degassification was employed to remove all possible traces of hydrogen.

The gray cast iron was produced from a malleable pig, additions being made to the charge to give a composition equivalent to that of the eutectic.

Both the cast iron and the steel, made from virgin stock, were melted under an argon cover to minimize oxidation.

Pouring temperatures were maintained as follows:

Aluminum alloy	—	1300 F (700 C)
Gray cast iron	—	2475 F (1360 C)
0.2 per cent Carbon steel	—	2950 F (1620 C)

The castings were subsequently sectioned in several planes, to determine the extent of under riser shrinkage. Measurements were also made of casting thickness to gage the mold dilation. In addition, supplementary measurements of the effect of mold dilation upon unfed aluminum bronze plates involved in previous work were made.[2] The critical ratio of V_R/A_R to V_C/A_C was determined by plotting this measured ratio against depth of unsoundness for particular riser combinations, e.g., cylinder feeding sphere. Figure 2 exhibits typical results for gray iron and aluminum alloy no. 13 cast into various molds. This method has been proposed previously.[6]

Results of Experiments

Given in Tables 4 to 8 are inferred K_s values for the experiments performed. These values were obtained by dividing the experimentally determined product ($K_s \cdot K_g$) by the approximate value of K_g, as calculated for plate-cylinder and sphere-cylinder combinations, without corner corrections. In the instances of the few 4 in. cubes cast it was deemed necessary to attempt to account for the corner effects using the Ruddle-Skinner correction.[7]

In Tables 4 and 5 the effects of mold shape are shown for 13 per cent silicon-aluminum alloy (no. 13) and the gray iron in green sand molds.

TABLE 4 — MOLD SHAPE EFFECT ON K_s VALUE FOR ALUMINUM ALLOY NO. 13 IN GREEN SAND MOLDS

Shape	Section Thickness, in.	Observed Critical Ratio* of V_R/A_R to V_C/A_C	Calculated K_g	Inferred K_s
Sphere	2	1.05	1.00	1.05
Sphere	4	0.82	1.00	0.82
Cube	4	0.92	1.00	0.92
Plate	2	1.04	1.17	0.89

* Equal to $K_g \cdot K_s$.

The 2 in. spheres in both alloys require the most feeding (as reflected by the large K_s) while the 4 in. spheres require the least. Intermediate values of K_s are held by the 2 in. plates and also the 4 in. cubes (The latter were determined for silumin alloy only).

Table 6 indicates the interdependence of K_s on both mold material and mold shape. The rigidity increase brings the K_s value down to 0.71 with the 2 in. diameter spheres in the silicon-aluminum alloy no. 13.

In plate castings the sodium silicate bonded sand deviated from this trend. Examination of the casting surface and the thickness profile indicated that the stress configuration for this mold shape, in combination with this particular mold material, had caused

a general mold cracking and irregular wall movement.

TABLE 5 — MOLD SHAPE EFFECT ON K_s VALUE FOR CAST IRON* IN GREEN SAND MOLDS

Shape	Section Thickness, in.	Observed Critical Ratio** of V_R/A_R to V_C/A_C	Calculated K_g	Inferred K_s
Sphere	2	1.05	1.00	1.05
Sphere	4	0.79	1.00	0.79
Plate	2	1.20	1.18	1.02

* Eutectic carbon equivalent.
** Equal to $K_g \cdot K_s$.

TABLE 6 — PARTIAL DEPENDENCE OF K_s ON MOLD SHAPE AND MATERIAL FOR ALUMINUM ALLOY NO. 13

Shape	Mold Material (Table 3), sand type	Section Thickness, in.	Observed Critical Ratio* V_R/A_R to V_C/A_C	Calculated K_g	Inferred K_s
Sphere	Green	2	1.05	1.00	1.05
Sphere	Cement bonded	2	1.00	1.00	1.00
Sphere	Core	2	0.96	1.00	0.96
Sphere	Sodium Silicate bonded	2	0.71	1.00	0.71
Plate	Sodium Silicate bonded	2	1.09	1.18	0.93
Plate	Green	2	1.08	1.17	0.89
Plate	Cement bonded	2	0.94	1.18	0.80

* Equal to $K_g \cdot K_s$.

With the 2 in. plates in gray iron (Table 7), a change in rigidity due to drying out of the mold occurs during the early part of the solidification in green sand. This has probably led to the feeding requirements being similar to those in cement bonded sand.

TABLE 7 — MOLD MATERIAL EFFECT ON K_s VALUE FOR GRAY CAST IRON CAST INTO 2 IN. PLATES

Mold Material, sand type	Observed* Critical Ratio V_R/A_R to V_C/A_C	Calculated K_g	Inferred K_s
Green	1.20	1.18	1.02
Cement bonded	1.20	1.18	1.02

* Equal to $K_g \cdot K_s$.

Table 8 gives comparison between 0.2 per cent steel and the 13 per cent silicon-aluminum alloy no. 13, cast as 2 in. diameter spheres in molds of various rigidities once again. It would appear that with the higher interface temperature material, early rigidity changes occur. These effects will be considered more fully in the discussion.

TABLE 8 — K_s VALUES FOR 0.2 PER CENT CARBON STEEL AND ALUMINUM ALLOY NO. 13 IN VARIOUS MOLDS FOR 2 IN. DIAMETER SPHERES

Alloy	Mold Material, sand type	Observed Critical Ratio* V_R/A_R to V_C/A_C	Calculated K_g	Inferred K_s
Steel	Green	1.08	1.00	1.08
Steel	Cement bonded	1.08	1.00	1.08
Aluminum	Green	1.05	1.00	1.05
Aluminum	Cement bonded	1.00	1.00	1.00
Aluminum	Core	0.96	1.00	0.96
Aluminum	Sodium silicate bonded	0.71	1.00	0.71
Cast Iron	Green	1.05	1.00	1.05

* Equal to $K_g \cdot K_s$.

Discussion and Conclusions

The wide range of values for the K_s shrinkage factor, contained in Tables 4 to 8, obtained for the short freezing range alloys indicates a strong dependence of feed metal requirements upon mold material, casting shape, section thickness and solidification temperature.

In general terms, provided no cracking of the mold material occurs, the more rigid the mold, the less the feeding requirements. If drying out occurs there is, for a particular mold cavity shape, little or no difference between the feeding requirements of castings produced in what initially were green sand molds as compared to those made in what were initially more rigid molds.

For a constant mold material, when mold shape is varied from a sphere to a plate, a change in feed metal requirement occurs. For casting solidification times of similar order (compare 2 in. plate, 4 in. sphere in green sand molds) more feed metal is demanded by the castings produced in a mold with the least restrained walls, i.e., plates.

Although only the bonding material of one particular sand has been varied in the present work, the effect of changes in the basic mold material will also be important. Figure 3 shows an indication of thickness profiles of unfed eutectic aluminum bronze plates poured into molds made with sands of varying coarseness and ramming density.

Finally, from the data currently presented, it would also appear that the sensitivity of feed metal requirement to differences in mold materials falls off with increasing solidification temperature and/or increasing section thickness of the alloy poured.

Before any further claims are made regarding a universal theory for the feeding of short freezing range alloys, full acknowledgment must be made of the aforementioned effects. These effects have not been taken into account by previous workers. Somewhat unsuitable graphical representations of data have therefore appeared. Ideally, there should exist a straight line relationship between the volume-to-surface-area ration V_R/A_R of the riser to that of the casting V_C/A_C which passes through the origin; the slope will depend upon the shape combination.

In practice, because of the limitations imposed by

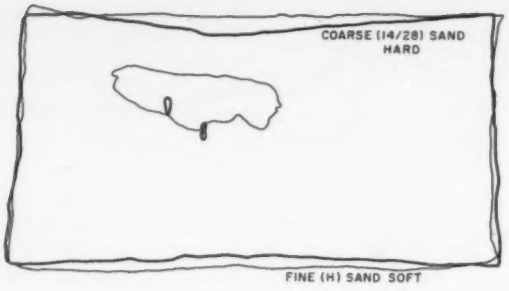
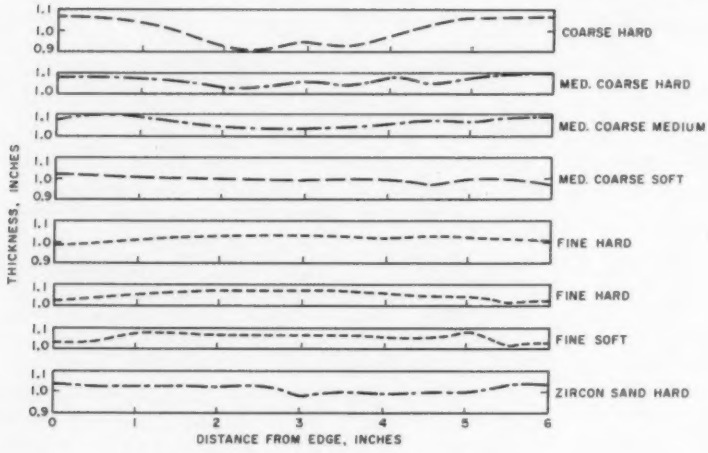


Fig. 3 — Mold material effect on casting shape (aluminum bronze eutectic).



the mold dilation effects, a ready, simple relationship cannot exist. However, it is reasonable to expect that a collection of calculated K_g and inferred K_s values can be steadily built up from past work as well as future data. This would be, in effect, determining the parts of particular straight lines adhered to for the feeding requirements of given families of castings. Recourse to the literature[4] indicates that this treatment need not be limited to simple-shape combinations but that the effects of appendages, etc., can also be accounted for (Table 9).

TABLE 9 — APPENDAGES EFFECT ON SHRINKAGE FACTORS[4]

Appendages	Appendage thickness, in.	Critical ratio, $V_E/A_E/V_C/A_C$ (parent casting)	K_g	Apparent K_s
		4 x 4 x 30 in. Bar		
Plate	½	1.16	1.2	0.97
	1	1.13	1.2	0.94
	2(longitudinal)	1.38	1.2	1.15
	2(transverse)	1.32	1.2	1.10
Bar	1	1.05	1.2	0.87
	2	1.06	1.2	0.88
	3	1.10	1.2	0.92
		4 x 20 x 20 in. Plate		
Plate	½	1.15	1.2	0.96
	2	1.28	1.2	1.07
	3	1.35	1.2	1.12
Bar	2	1.15	1.2	0.96
	4	1.26	1.2	1.05
	6	1.30	1.2	1.08

NOTE: K_g as calculated does not take into account appendages or corner effects.

DISPERSED SHRINKAGE PROBLEM

Present State of Knowledge

According to Baker[8] long freezing range alloys solidify in sand molds in a pasty fashion and are fed in two distinct phases:

1) Mass feeding. This involves the sinking and transport of semisolid material within the casting. Transport is clearly influenced by the metallostatic and atmospheric or applied pressure.

2) True liquid metal feeding through the tortuous paths that occur as a result of the solidification mode and mass feeding.

It has been further suggested by Cibula and Jay[9] that feeding persists until at least 60 per cent of the metal has solidified.

From the variables treated previously an impression of the methods open to attack may be gained:

1) Inherent properties of the metal during solidification are obviously fixed by choice of alloy system employed for the casting.

2) Local thermal conditions have been manipulated by Johnson, Pellini and Bishop[10] by the use of chilling techniques.

3) Effective pressure differential is dependent only, in normal casting techniques in a particular alloy at a particular temperature, on metallostatic head.

An essential feature of all the feeding methods adopted is the use of the metallostatic and atmospheric pressure to force feed the liquid metal into the casting. The only commercial methods at present where pressures greater than atmospheric are used are centrifugal casting and pressure die casting. The soundness and integrity of centrifugal castings is well known and, in view of the success of this technique, it should be possible to produce sounder castings by normal foundry techniques by the application of feeding pressures much in excess of those presently employed.

Both phases of feeding will clearly be affected by increased feed pressure.

The use of additional agents to procure relatively high pressures in feeder heads of steel castings has been reported by a few investigators. This recently reported work has been performed principally in Eastern Europe or the Soviet Union. Desnizki[11] employed compressed air at pressures up to 70 psi on the feeder head of steel castings approximately 10 ft long by 15 in. wide by 2½-in. thick. Jazwinski[12] has adopted a sophisticated self-pressurizing system involving a check valve incorporated into the down sprue. The linseed oil based pressurizing charge is closely similar in concept to Pearson's[13] refractory-coated lead nail. The application of steam feeding to large gray iron castings has, of course, been employed in certain iron foundries for a number of years.

Long Freezing Range Alloys

The effects of the application of pressure to long freezing range aluminum alloy castings during solidification has been studied by a number of workers. Hanson and Slater,[14] Parker[15] and Uram,[16] with their respective co-workers, have been prominent in this field. Although the work of Parker, etal, and Uram, etal, was performed in autoclaves under approximately equivalent conditions, the results obtained from physical tests of the castings were not in agreement. Specifically, Parker reported a 10 per cent increase in ultimate tensile strength and an increase of 30 per cent in elongation in high purity 220 aluminum alloy, well degassed with chlorine. However, Uram, working with aluminum alloys 356 and 195, reported no increases in either property concurrent with the application of pressure. Neither of the techniques adopted appear to take full advantage of the effect of applied pressure upon mass feeding. Ideally, as previously stated, a pressure differential should be promoted to effect markedly the mass transport of the semisolid feed metal.

In addition, the long freezing range alloys, normally assumed to be nonskin formers, under certain metallurgical conditions, can effectively behave partially at least as skin forming alloys. Cibula[17] observed that a transition from skin forming to pasty solidification is strongly dependent on pouring temperature when gun metal and bronzes are cast into the sand molds—high pouring temperatures lead to skin formation—presumably reflecting the reduction in number of nuclei present in the pouring stream.

Experimental Techniques

Three aluminum alloys selected for the investigation were:

Alloy No.	Composition, %				
	Cu	Fe	Si	Mg	Ti
43	0.00	0.36	4.89	0.01	0.12
220	0.13	0.07	0.09	10.14	0.09
355	1.17	0.25	4.90	0.45	0.10

The respective freezing ranges of these three alloys[18] are:

Alloy No.	Liquidus, F (C)	Solidus, F (C)
43	1165 (629)	1070 (577)
220	1150 (621)	840 (499)
355	1160 (627)	1075 (579)

Two different castings were chosen for the work, one to be 2 in. square in cross-section by 14 in. long and the other to be 4 in. square by 26 in. long. If castings of these dimensions are run and fed from one end, then shrinkage porosity will certainly occur when cast in the above aluminum alloys.

Figure 4 shows the pattern for the 2 in. square cross-section casting. The molds were made in oil-bonded core sand. Figure 5 shows a schematic view of the casting. The plaster-of-paris cap which is used for retaining gas pressure on the feeder can be seen. Shown in Fig. 6 is an aluminum alloy casting produced without pressure application to the head.

The aluminum alloys were melted in a 70 lb aluminum capacity carbon/clay crucible surrounded by a high frequency drop coil. The absorption of hydrogen from water vapor or other sources is normally negligible in this type of melting; nevertheless, the melts were vigorously degassed with dry chlorine gas admitted to the melt by means of a submerged refractory tube. The casting temperature for the 4 in. square cross-section test bars was 1290 to 1310 F and for the 2 in. square cross-section test bar, 1310 to 1330 F.

Standard vacuum degassification tests were conducted on samples of the liquid metal from selected melts to check the efficiency of the chlorine degassing operation.

Dry argon gas was utilized for pressurizing the feeder head. In the initial experiments, considerable difficulty was experienced because of extreme metal penetration into the oil-bonded core sand molds. Figure 7 illustrates the severity of this metal penetration. To overcome this effect a colloidal silica mold wash was applied to the mold faces; the application of gas pressure was delayed for 30 sec in the case of the 2 in. square test bar and 2 min in the case of the 4 in. square test bar. By employing these techniques cast-

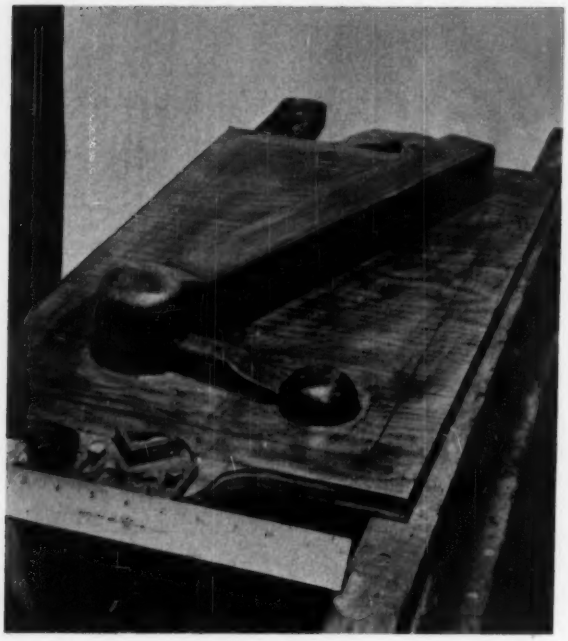


Fig. 4 — Pattern for 2 in. square cross-section test casting.

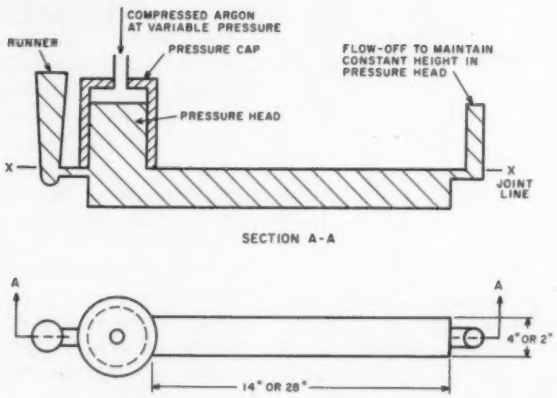


Fig. 5 — Schematic view of test casting with pressure cap.

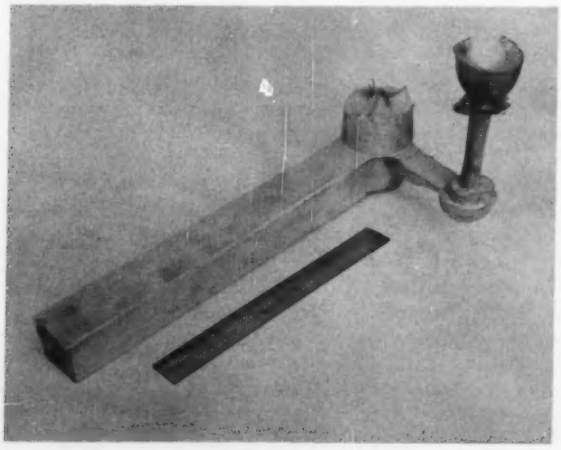


Fig. 6 — Trial 2 in. square cross-section test casting (no pressure applied).

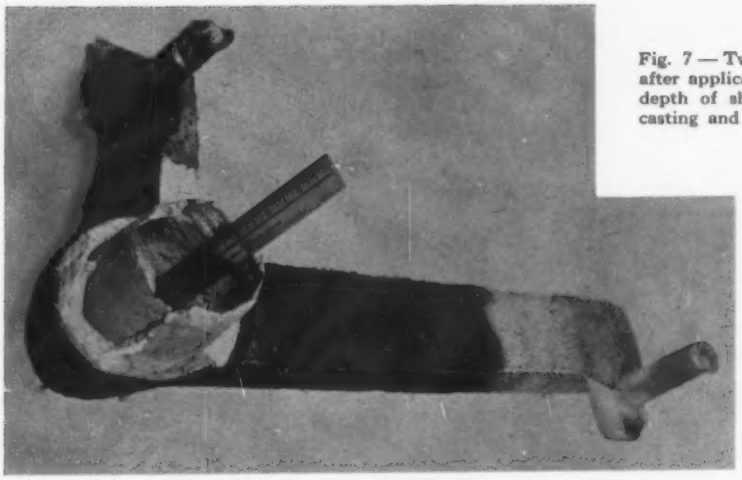


Fig. 7 — Two in. square cross-section aluminum casting after application of 20 psi pressure to feed head. Note depth of shrinkage cavity in feeder and swelling of casting and metal penetration of sand.

ings were produced which had satisfactory surfaces and shapes.

To evaluate the performance of the technique, 1/8-in. cross-sectional slices were machined from the bars at 2 in. intervals along their length. These slices were subjected to careful radiographic examination.

Results of Experiments

Illustrated in Fig. 8 are two views of sectioned feeder heads. The heads were taken from 2 in. square castings produced in aluminum alloy no. 43. The feeder head shown in Fig. 8a was taken from a casting which had an indicated pressure of 10 psi dry argon gas applied to it. The feeder head shown in Fig. 8b was taken from a casting which did not have any supplementary pressure applied.

Both of the feeder heads or risers were surrounded by a plaster-of-paris sleeve to retard solidification and ensure that the metal in the risers did not solidify before the castings proper.

The effect of the application of pressure can readily be observed. The inner surfaces of the shrinkage cavity in the pressure head had an appearance similar to that normally associated with hot tear faces, indicating that semisolid or pasty feed metal had been forced by the applied pressure in the casting.

Aluminum Alloy No. 43

As previously stated radiographic examination of cross-sectional slices taken from the 2 in. and 4 in.

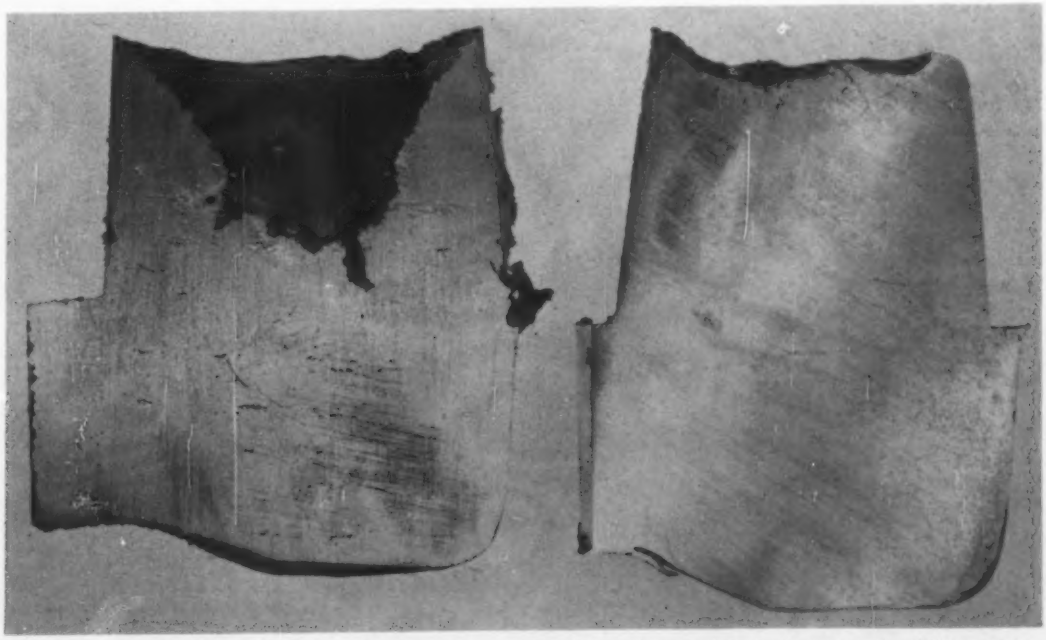


Fig. 8 — Section feeder heads from two aluminum alloy 43 castings (original size of head — 3¾-in. high above cope face of casting, 3½-in. diameter). *Left* — 10 psi applied pressure. *Right* — no applied pressure.

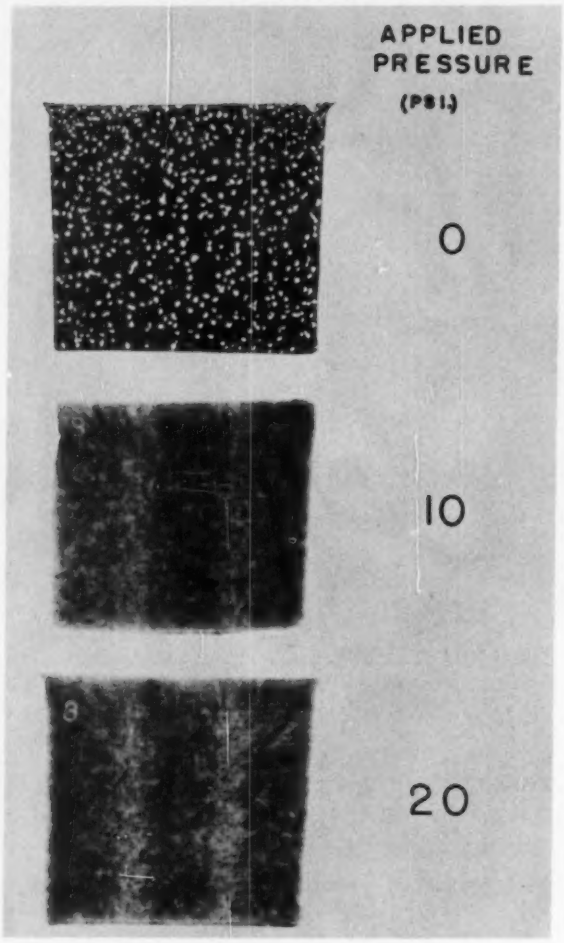


Fig. 9 — Radiographs of slices taken from the center section of 2 in. square cross-section casting in aluminum 43.

square bars was used as the criterion for the success or failure of the pressure application to the feeder head. It was considered that the area or zone which would be most prone to dispersion shrinkage would be approximately in the center of the bar. Accordingly, exhibited in Fig. 9 are the radiographs of ⅛-in. slices taken at sites 8 in. from the end of three bars. The upper radiograph relates to the slice from the casting produced without any applied pressure.

The center radiograph was taken from a casting which has 10 psi indicated argon gas pressure applied to it, and the lower radiograph taken from a slice of the casting with 20 psi indicated argon gas pressure. The effect of the gas pressure can readily be observed. All traces of interdendritic porosity have been eliminated by the application of 10 psi argon gas to the feeder head. Shown in Fig. 10 are radiographs taken from slices which originated at a position 12 in. from the end of the 4 in. square test bar castings.

The upper radiograph is taken from a casting with no supplementary pressure applied; the center radiograph is with 10 psi applied pressure and the lower radiograph is with 20 psi applied argon pressure. The results obtained here are not so spectacular as those obtained from the 2 in. square bar, but the reduction in shrinkage is readily apparent.

Aluminum Alloy No. 220

Figure 11 shows a similar series of radiographs to those exhibited in Fig. 9, except that the aluminum alloy investigated was no. 220, which has an extremely long freezing range.

The reduction and elimination of interdendritic shrinkage can be seen from these radiographs.

Figure 12 shows radiographs taken from the central portion of two 4 in. square cross-section castings. The effect of 20 psi indicated gas pressure upon the incidence of dispersed shrinkage is apparent. The upper radiograph relates to a casting produced without benefit of supplementary pressure, and the lower one after the application of 20 psi argon gas during solidification.

Aluminum Alloy No. 355

Exhibited in Fig. 13 are radiographs of ¼-in. slices taken from 2 in. square cross-section castings made from Alloy No. 355. The upper radiograph relates to a casting produced by ordinary techniques, the center radiograph with 10 psi applied argon pressure and the lower one with 20 psi applied argon pressure. Again, the reduction in shrinkage is apparent when supplementary gas pressure is applied to the feeder head.

Figure 14 shows the effect of applying up to 20 psi indicated argon pressure to the 4 in. square cross-section castings. Although the interdendritic shrinkage is still present in the casting which had the benefit of pressure application, the severity of this defect is considerably reduced.

Conclusion and Discussion

The success of the pressurizing technique on feeder heads of the selected long freezing range aluminum alloys, indicates that this method could be used for the production of castings with complete structural integrity.

Techniques which involve the deliberate partial gassification of aluminum alloys to reduce feeding problems cannot make this claim. This type of defensive approach is hardly desirable.

Similarly, the approach adopted in some bronze and gun metal foundries, involving high pouring temperatures of fully degassed metal, leading to casting sections, possessing only two or three grains per cross-section, should be deplored.

While the application of this technique does involve certain difficulties connected with breakout and metal penetration affects, it is considered that, for the production of the best quality castings in long freezing range copper and aluminum based alloy, this approach could profitably be investigated. Further, the possibility does exist that a self-pressurizing feeder head could be made wherein a plug of gas producing material, such as hexachlorethane, is located.

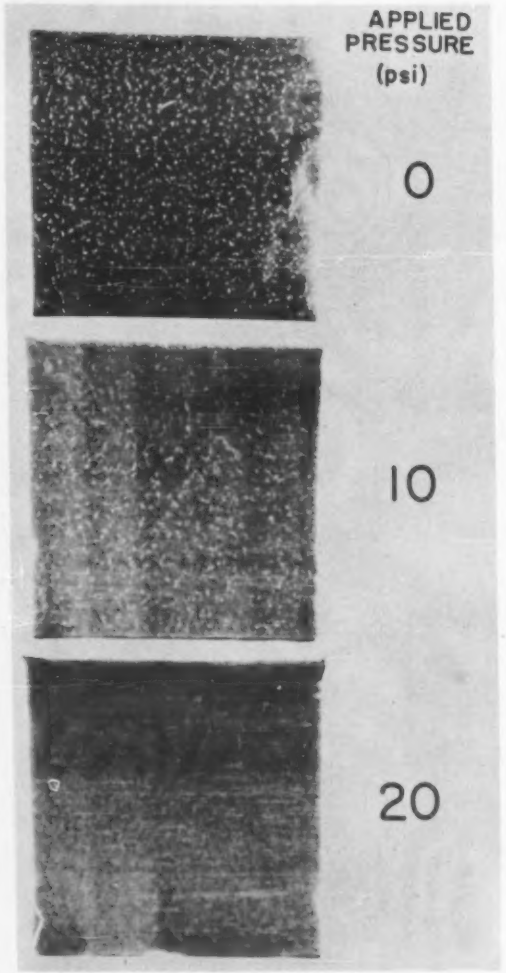


Fig. 10 — Radiographs of slices taken from the center of 4 in. square cross-section bar casting in aluminum 43.

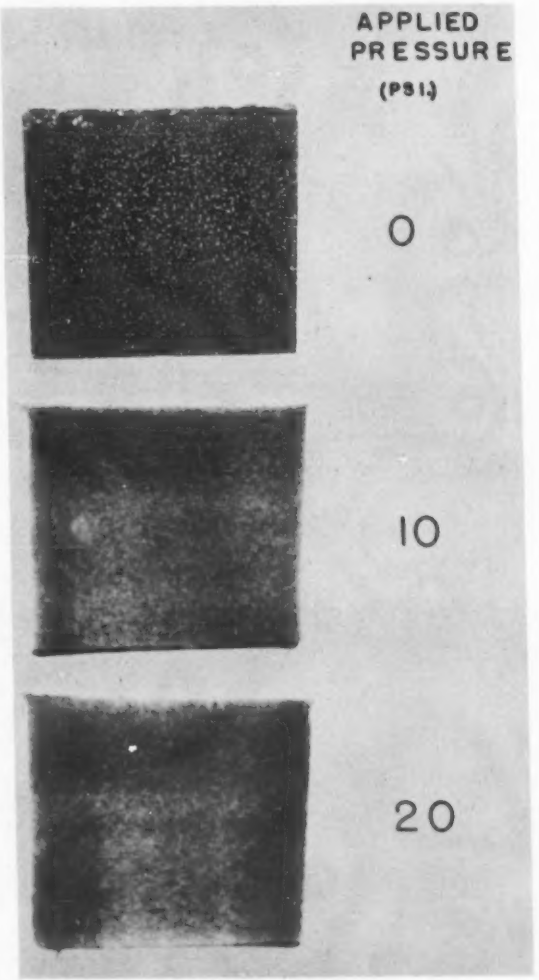


Fig. 11 — Radiographs of slices taken from center of 2 in. square cross-section bar casting in aluminum 220.

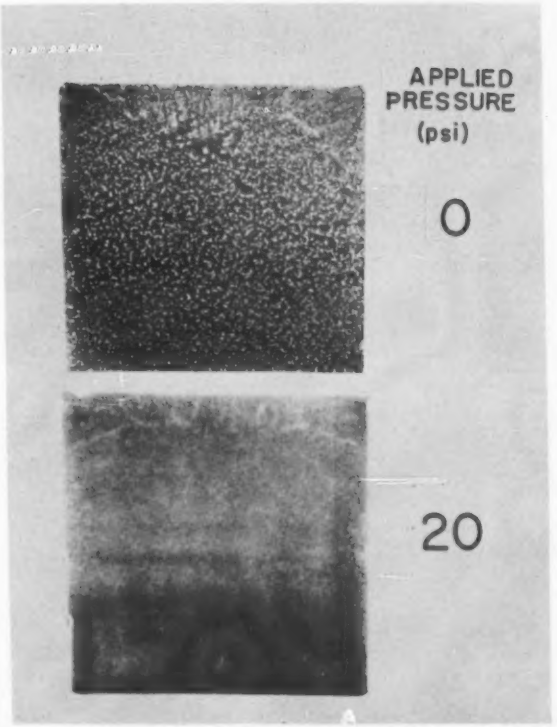


Fig. 12 — Radiographs of slices taken from center section of 4 in. square cross-section bar casting in aluminum 220.

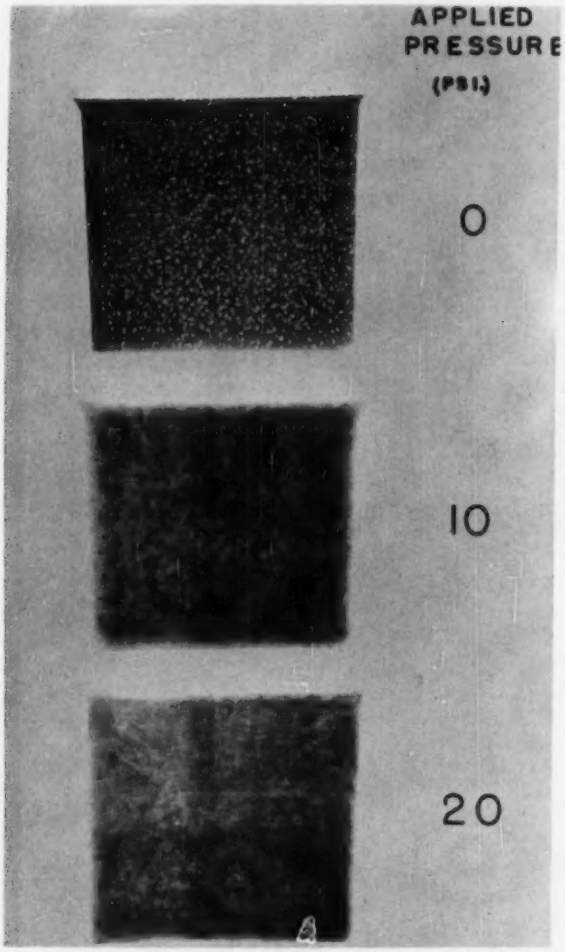


Fig. 13 — Radiographs of slices taken from center section of 2 in. square cross-section bar casting in aluminum 355.

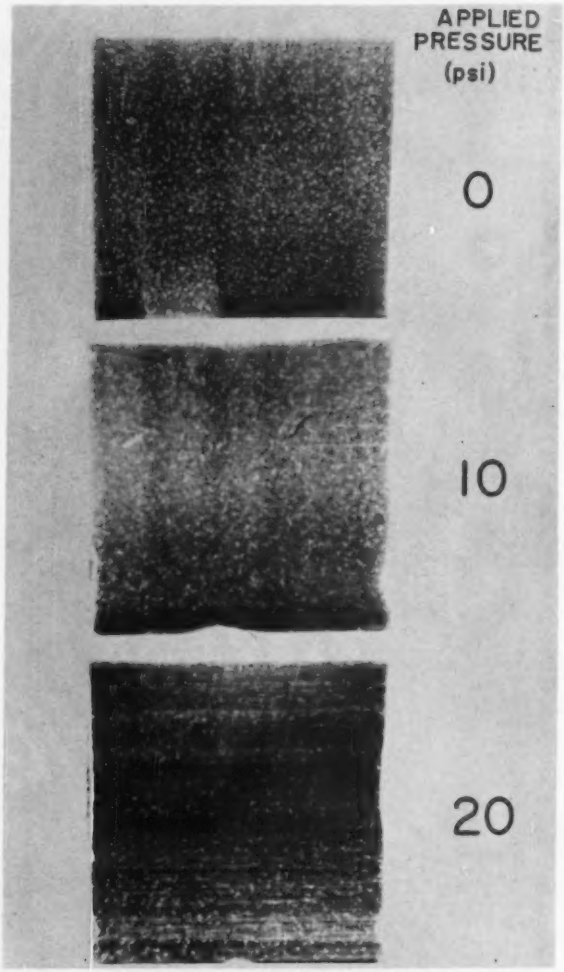


Fig. 14 — Radiographs of slices taken from center section of 4 in. square cross-section bar casting in aluminum 355.

Finally the application of the technique to skin forming alloys such as steels, aluminum oronzes, etc., represents a highly desirable means of minimizing centerline shrinkage in thin section castings where conventional feeding ranges are exceeded.

SUMMARY

Any rationalized approach to the problem of precise feeding of short freezing range alloys will have to account for the mold, as well as heat transfer, variables described in the present work such as mold cavity shape, mold materials, section thickness and metal cast. Previous methods of dimensioning have oversimplified this problem.

In the production of castings of thick sections and high integrity, due consideration to the application of supplementary feed pressure to the risers should be given. Although experimental difficulties may be encountered, these should not prove insurmountable.

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CHILLING BEHAVIOR OF A ROLL-TYPE CAST IRON

Some factors affecting

by K. E. Pinnow and R. W. Lindsay

ABSTRACT

Superheating temperature, pouring temperature and charge materials effects on the chill characteristics of a roll-type cast iron were evaluated by making chill castings from melts of constant chemical composition. Superheating temperatures and pouring temperatures were precisely measured by immersion thermocouples.

An increase in superheating temperature from 2600 to 2900 F (1427 to 1593 C) increased the chill capacity of melts poured at 2450 F (1343 C). A decrease in pouring temperature from these superheating temperatures to 2450 F reduced chill depth. Differences in melting stock had a marked effect on the chilling behavior of melts heated to low superheating temperatures (2600 F), but had less influence on those superheated to high temperatures (2900 F).

Superheating temperature did not markedly affect the structure of the white iron and gray iron portions of the chill test castings. Lowering the pouring temperature from the superheating temperature to 2450 F produced noticeable changes in the white iron structure.

The exact causes for the changes in chill behavior produced by these variables were not determined. However, they were not a direct result of differences in customary chemical composition nor perhaps in gas content between melts superheated to different temperatures.

INTRODUCTION

The chilling behavior of cast iron is of prime concern to producers of chilled cast iron rolls, as well as to all foundrymen involved in the manufacture of chilled castings. Chemical composition has a pronounced effect on this behavior, and the influences of the elements commonly found in cast iron have been well established. Elements such as carbon, silicon and nickel retard the formation of carbide during solidification; and those such as chromium, manganese and sulfur promote it.

Hydrogen and nitrogen are considered to behave like the latter elements, whereas oxygen has been reported to have a carbide-stabilizing influence, a graphitizing influence, or perhaps no effect at all.[1-4]

Other important, but less obvious factors affecting chilling behavior are superheating temperature, pouring temperature and the nature of the charge materials. Increased superheating temperature has been observed to increase the depth of white iron formed in chilled castings poured at identical temperatures, while reducing the casting temperature below the superheating temperature has been found to decrease it.

Melts produced from different charges often exhibit differences in chilling behavior even though their customary chemical composition is similar. The exact explanations for these effects have not been determined, but they have been attributed variously to differences in the amount of graphite in the charge (graphite nuclei theory), variations in the hydrogen and oxygen contents of the melt (gas content theory) and the presence or absence of certain nonmetallic nuclei (silicate-slime theory).[5-7]

Much of the work in which these aforementioned results were obtained is subject to question on the basis that the chemical composition of the experimental melts was not kept constant, nor were the superheating and pouring temperatures accurately controlled or measured. The purpose of this investigation was to determine the influence of superheating temperature, pouring temperature and charge materials on the chilling behavior of a roll-type cast iron under conditions of constant chemical composition and exact temperature control.

MATERIALS AND EXPERIMENTAL PROCEDURE

Roll iron, low-sulfur pig iron, graphite, ferrosilicon (47 to 51 per cent silicon) and ferromanganese (70 to 80 per cent manganese) were used to prepare the experimental melts. The roll iron was obtained from castings poured from two different roll heats. The castings were made in green sand molds with a diameter of 10 in. and a depth of 40 in., and thus corresponded closely to actual roll castings. The chemical

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compositions of the roll iron and the pig iron are given in Table 1.

TABLE 1— CHEMICAL COMPOSITIONS OF CHARGE MATERIALS

	Weight, %						
	TC*	GC**	Si	Mn	P	S	Mo
Roll Iron, Lot No. 1	3.30	1.67	0.62	0.24	0.450	0.110	0.37
Roll Iron, Lot No. 2	3.30	n.a.	0.74	0.25	0.444	0.107	0.34
Pig Iron	4.12	3.08	0.97	0.27	0.62	0.058	n.a.

*TC — total carbon.
**GC — graphitic carbon.
n.a. — not analyzed.

The basic charge for the melts used to study the effects of superheating temperature and pouring temperature was 40 lb of roll iron from lot No. 1 and 60 lb of roll iron from lot No. 2. Depending on the superheating temperature involved, different amounts of ferromanganese, graphite and ferrosilicon were added to such a charge to adjust the manganese content and to compensate for the losses of carbon and silicon which occurred during melting. These additions were made early during meltdown to avoid inoculation effects.

The heats produced to study the influence of charge materials were made from different proportions of roll iron, pig iron, ferrosilicon and ferromanganese. In these melts the carbon and silicon contents were controlled by varying the amounts of pig iron and ferrosilicon. The manganese content was adjusted by making small additions of ferromanganese.

The experimental melts were made in a 100 lb capacity induction furnace, lined with a commercial magnesia crucible. Magnesia crucibles were used in order to minimize metal-crucible reactions. Subsequent chemical analyses of two melts, one superheated to 2600 F (1427 C) and the other to 2900 F (1593 C), indicated that the magnesium contents of both melts were quite low (less than 0.001 per cent). Thus, it was assumed that magnesium contamination was not a factor in these experiments.

Melting Procedure

The melting procedure for each melt consisted of placing one-half of the charge into the crucible. The unit was then energized with an input that was kept constant until the desired superheating temperature was reached. After the first portion of the charge began to melt, more roll iron or pig iron was added until about 20 lb of material remained uncharged.

At this point the metal was allowed to become completely molten, and then, in the following order, additions of ferrosilicon, ferromanganese and graphite were made (Graphite additions were not made to the melts prepared with pig iron). When these materials had dissolved, the remainder of the roll iron or pig iron was added. The melt was then heated to the superheating temperature and held at this temperature for 15 min.

The temperature of the melt was measured frequently during the holding period, as well as throughout the entire melting cycle, by an immersion thermocouple. Changes were made in the power input if necessary to maintain the temperature. It was difficult to keep the temperature constant by this technique, but temperature fluctuations were kept within ± 20 F of the superheating temperature.

At the end of the holding period the furnace was shut off, and in the following order a sample for chemical analysis and two chill tests were poured. After this, the metal which remained in the crucible was allowed to cool to 2450 F (1343 C) and another sample for chemical analysis and two more chill tests were cast. The chill test castings poured at the superheating temperature were designated as *A* and *B*; those cast at 2450 F (1343 C) as *C* and *D*.

The chill behavior of any melt was determined by pouring the metal directly from the furnace into a vertical, dry sand mold fitted with a horizontal, ingot iron chiller plate. The casting was shaken out 30 min after pouring, cooled to room temperature and fractured for visual examination. The depth of white iron and the character of the mottle in the castings were then used to evaluate chill behavior. The design of the chill test casting was the same as that used by the British Cast Iron Research Association.[8] Its shape and dimensions are shown in Fig. 1.

EXPERIMENTAL RESULTS

The chemical compositions of the chill tests, and their pouring temperature together with the superheating temperature of the melt from which they were cast, are given in Table 2. It is evident from these data that the chemical compositions of the chill castings are quite similar, despite differences in the super-

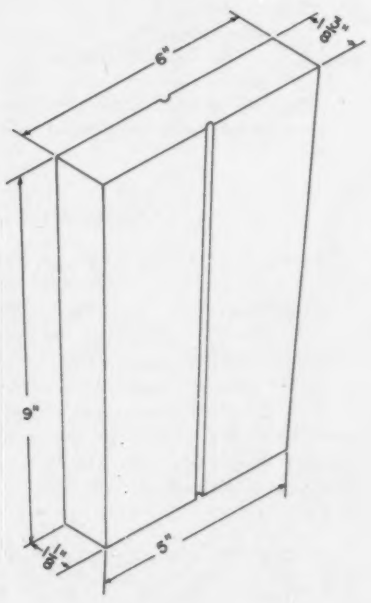

Fig. 1 — Chill test casting.

heating temperature, pouring temperature and the charge makeup of the melts from which they were produced.

TABLE 2 — CHEMICAL COMPOSITIONS OF CHILL TEST CASTINGS

Chill Test No.	Superheating Temp., F	Pouring Temp., F	Weight, % C	Si	Mn	P	S
1A, 1B	2600	2600	3.29	0.77	0.27	0.418	0.108
1C, 1D	2600	2450	3.28	0.76	0.28	0.406	0.107
2A, 2B	2700	2700	3.31	0.75	0.37	0.456	0.148
2C, 2D	2700	2450	3.31	0.74	0.34	0.434	0.114
3A, 3B	2800	2800	3.31	0.75	0.37	0.456	0.143
3C, 3D	2800	2450	3.30	0.74	0.36	0.402	0.138
4A, 4B	2900	2900	3.35	0.77	0.35	0.454	0.132
4C, 4D	2900	2450	3.31	0.75	0.31	0.450	0.140
5A, 5B	2600	2600	3.27	0.74	0.35	0.478	0.092
5C, 5D	2600	2450	3.30	0.74	0.32	0.462	0.115
6A, 6B	2900	2900	3.35	0.74	0.34	0.436	0.079
6C, 6D	2900	2450	3.29	0.75	0.35	0.416	0.090

Melts 1-4 produced from roll iron, graphite, ferrosilicon and ferromanganese; melts 5 and 6 from roll iron, pig iron, ferromanganese and ferrosilicon.

The results of vacuum fusion gas analyses, which were made on samples cast from two melts prepared principally from roll iron, are given in Table 3. The samples were taken from the white iron castings made for chemical analysis. Because the samples were not properly refrigerated before analysis, the values for hydrogen may not be representative of the hydrogen content of the melts before casting. It is interesting to note, however, that the gas contents of all the samples were about the same.

TABLE 3 — VACUUM FUSION GAS ANALYSES

Chill Test No.	Superheating Temp., F	Pouring Temp., F	Weight, % O_2	N_2	H_2
1A, 1B	2600	2600	0.0073	0.0040	0.00033
1C, 1D	2600	2450	0.0068	0.0040	0.00027
4A, 4B	2900	2900	0.0067	0.0050	0.00016
4C, 4D	2900	2450	0.0072	0.0040	0.00015

Superheating Temperature, Pouring Temperature and Melting Stock Effect on Chill Formation

The combined influence of superheating temperature and pouring temperature on chill behavior is shown in Fig. 2. Only the fractures of the *B* and *D* tests are shown, since the fractures of the matching tests were essentially the same. Reading from left to right, the melting and pouring temperature for each test was 2600 F (1427 C), 2700 F (1482 C), 2800 F (1538 C) and 2900 F (1593 C). It is evident that the depth of chill and the dispersion of the mottle increase as the superheating temperature and pouring temperature are increased from 2600 to 2900 F (1427 to 1593 C).

The effect of superheating temperature on chill capacity is shown in Fig. 3, where the chill tests were taken from melts superheated to 2600 F, 2700 F, 2800 F and 2900 F, as shown from left to right. The casting temperature in each case was 2450 F. There is an increase in chill depth and in the dispersion of the mottle as the melting temperature increases from 2600 to 2900 F. The effect of raising the temperature from 2800 to 2900 F, however, was not as pronounced as that obtained by increasing it from 2700 to 2800 F.

The influence of pouring temperature on chill behavior can be seen by comparing the chill tests shown in Figs. 2 and 3. It is clear that for a given melt, the chill depth is reduced by lowering the pouring temperature from the superheating temperature to 2450 F.

The differences in chill behavior produced by changes in the nature of the charge at low superheating temperatures are shown in Fig. 4. From left to right, in Fig. 4, the first two castings were taken from irons melted and cast at 2600 F and the second two from irons melted at 2600 F but poured at 2450 F. The first and third castings were prepared principally from roll iron and graphite, whereas the second and fourth were produced from roll iron and pig iron. It is quite evident that the chill depth in the castings is markedly different despite similar composition.

The changes in chill characteristics, produced by differences in the nature of the charge at high superheating temperatures, are shown in Fig. 5. Reading left to right, the first pair of tests was cast from metal melted and cast at 2900 F and the second pair of tests from metal melted at 2900 F and poured at 2450 F. The first and third tests were prepared primarily from roll iron and graphite, while the second and fourth were produced essentially from roll iron and pig iron. Here again, the castings produced from roll iron exhibited less chill than the ones made from roll iron and pig iron. The differences, however, are not as pronounced as those in the case of melts superheated to lower temperatures.

Melting and Pouring Temperature Influence on the Microstructure of the Chill Test Castings

Samples for metallographic examination were taken from the gray and white iron portions of the chill test castings used in the investigation of superheating temperature and pouring temperature. The structure of the white iron was examined at the chilled surface of each casting; at ¼-in. from the chilled surface; and at ½-in. from the chilled surface. Specimens used to examine the gray iron portion of the chill test castings were taken 5 in. from the chilled surface.

The microstructures in the white iron locations in castings, poured at 2600 F (1427 C) and 2450 F (1343 C) from a melt superheated at 2600 F, are shown in Fig. 6. Those for the same locations in castings poured at 2900 F (1593 C) and 2450 F (1343 C) from a melt superheated to 2900 F, are presented in Fig. 7. It is evident that superheating temperature, in itself, has no noticeable effect on the structure of the chill. However, pouring temperature does have an influence.

The structure in the castings poured at the superheating temperature is in general columnar and strongly oriented toward the chilled surface, whereas the structure in those poured at 2450 F is more

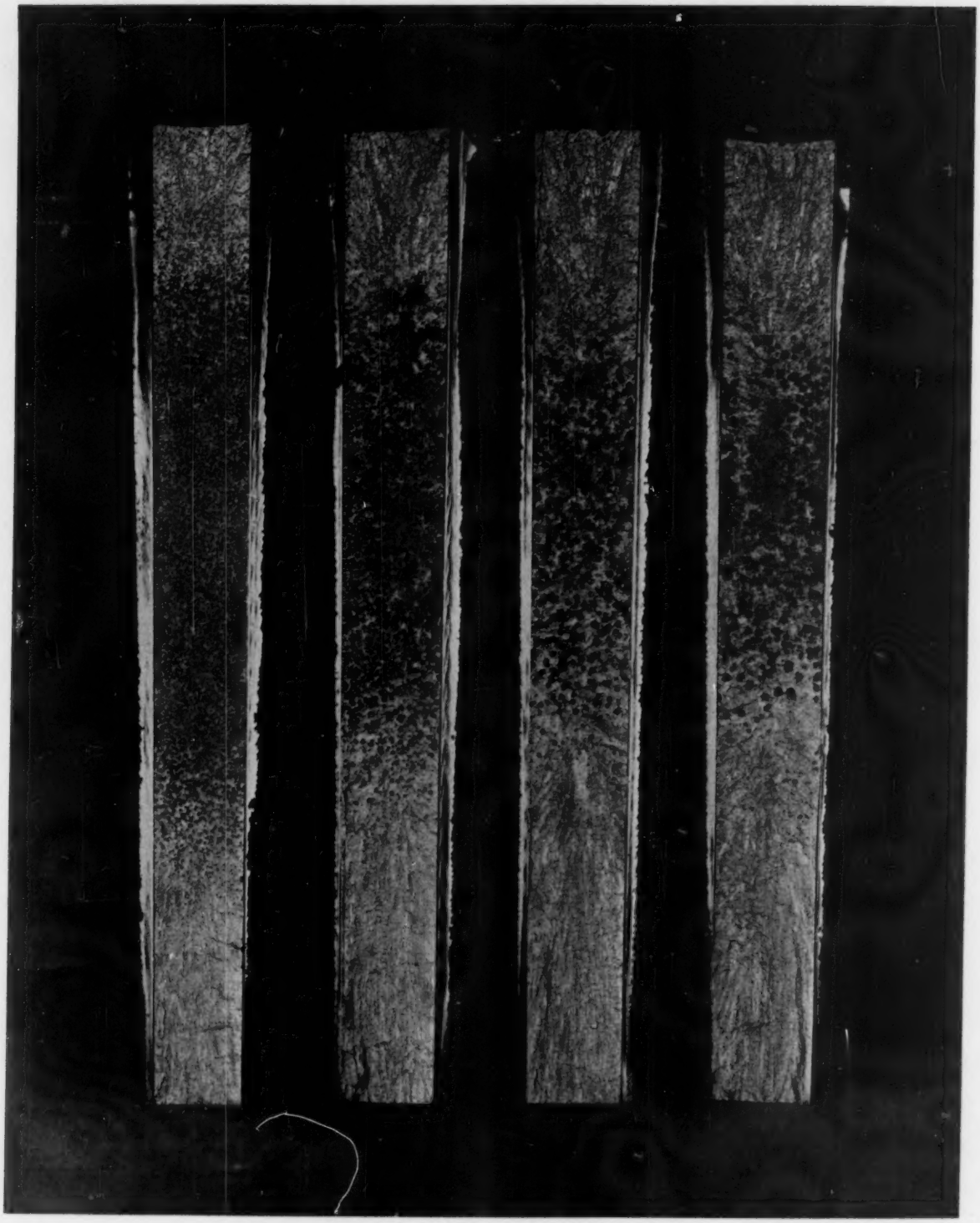

Fig. 2 — Combined influence of superheating and pouring temperature. Chill test — left to right — 1B, 2B, 3B, 4B.

Fig. 3 — Superheating temperature effect. Chill tests — left to right — 1D, 2D, 3D, 4D.

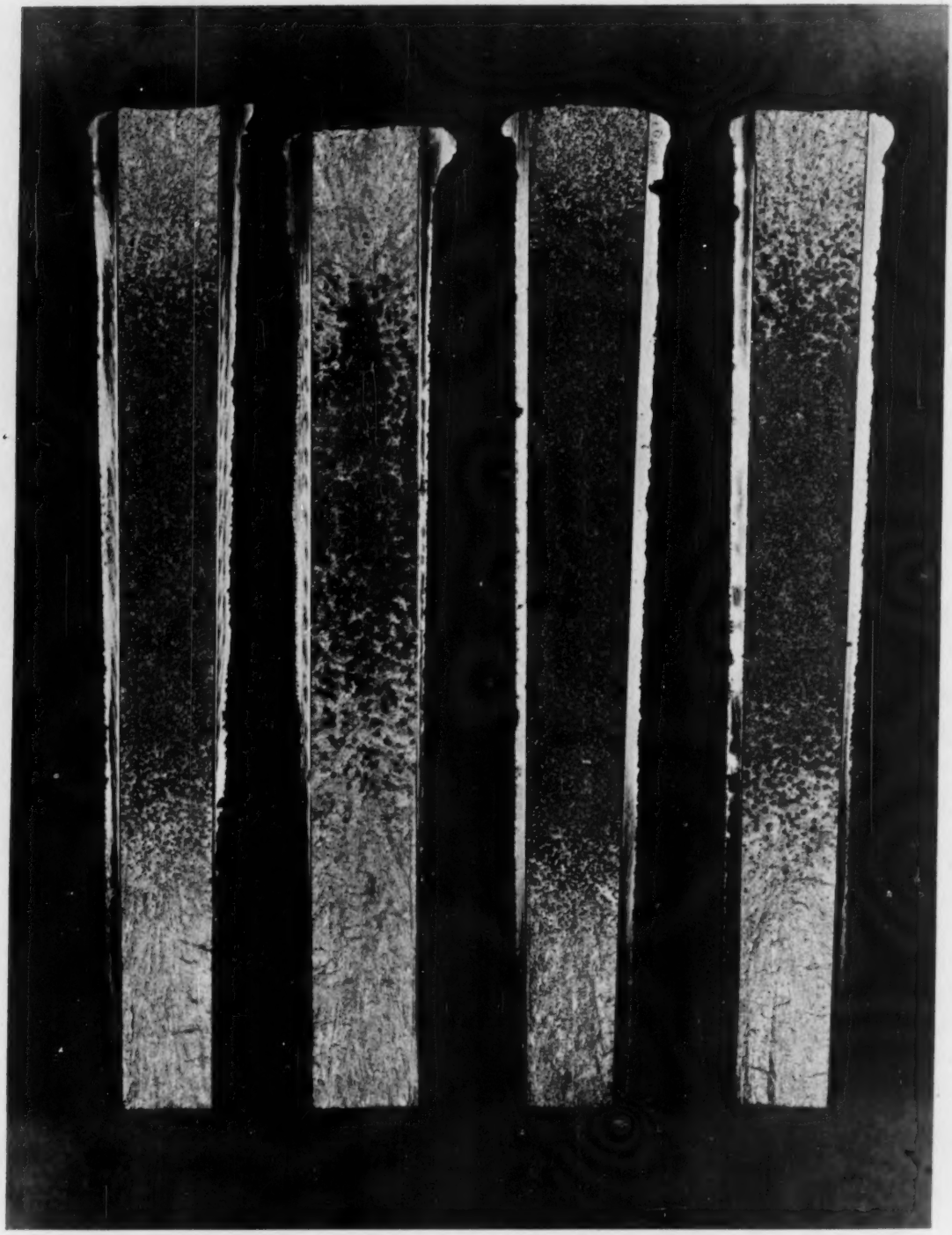

Fig. 4 — Charge materials influence on chill behavior at a superheating temperature of 2600 F. Chill tests — left to right — 1B, 5B, 1D, 5D.

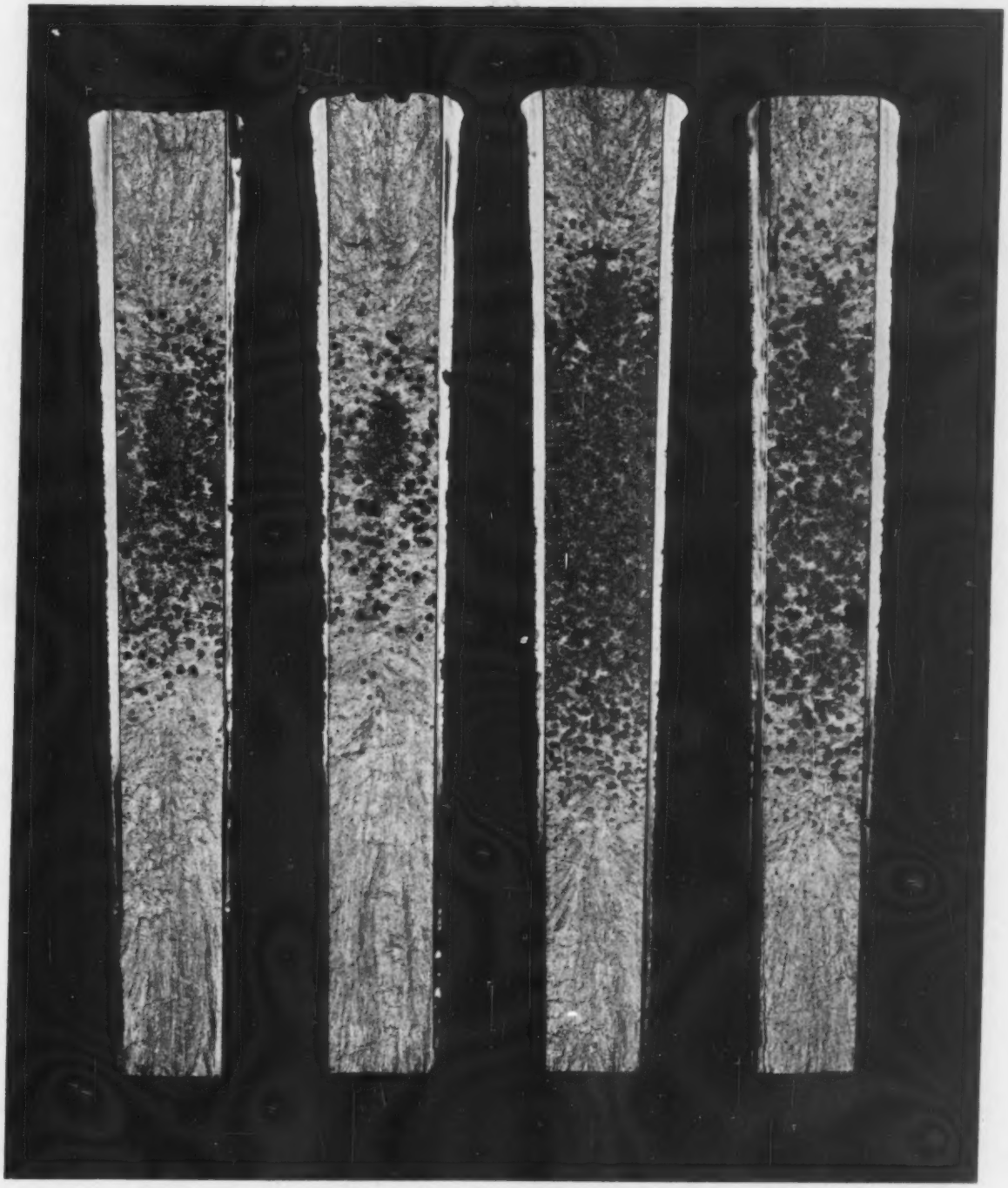

Fig. 5 — Charge materials influence at superheating temperature of 2900 F. Chill tests — left to right — 4B, 6B, 4D, 6D.

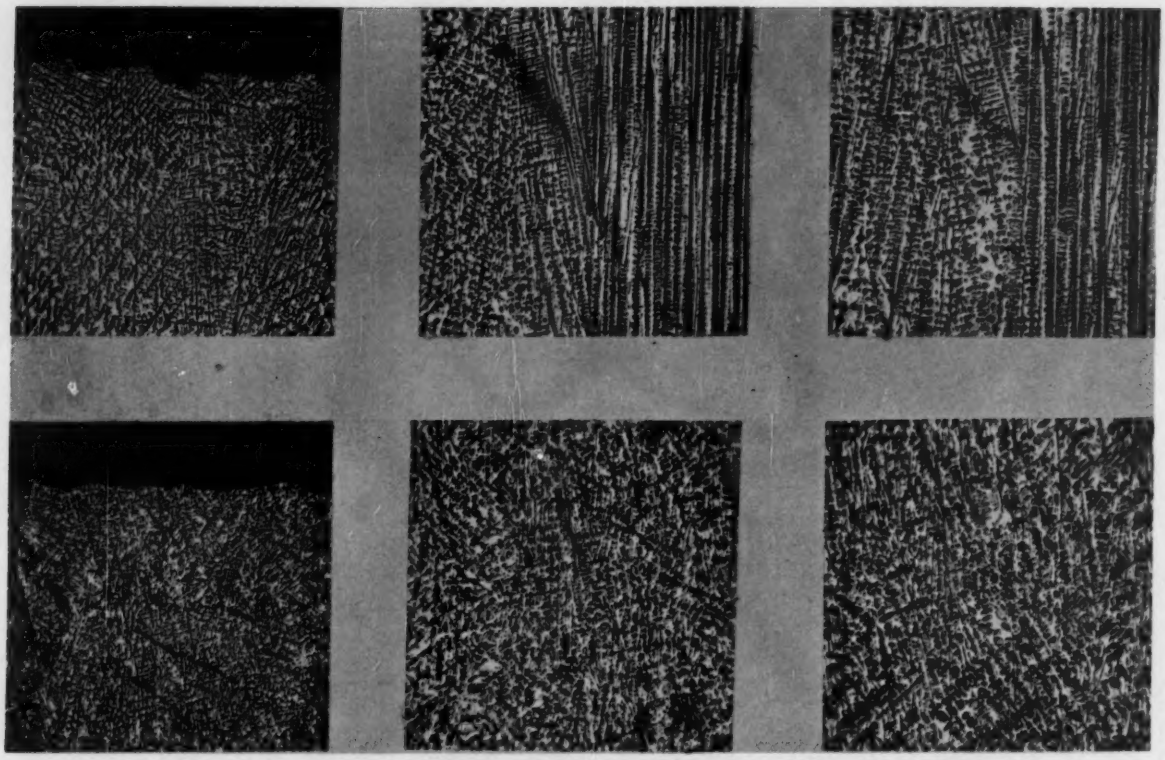

Fig. 6 — Microstructure of chill test castings at specified distances from surface of chill. *Top row* — superheating temperature — 2600 F; pouring temperature 2600 F. *Bottom row* — superheating temperature — 2600 F; pouring temperature 2450 F. Left to right — adjacent to chill, ¼-in. from chill and ½-in. from chill. 4 per cent nital etch. 25 ×.

random and does not exhibit any marked orientation toward the chill surface.

Metallographic examinations were made of the graphite flake distribution, matrix structure and cell size in the samples taken from the gray iron portion of the chill test castings. In general, it was found that neither superheating temperature nor pouring temperature had any marked effect on these features of the microstructure. Somewhat larger amounts of excess carbide were present in the castings poured from melts superheated to 2800 F (1538 C) and especially 2900 F (1593 C), but no other differences were evident. Photomicrographs illustrating the typical distribution and size of the graphite flakes, and the structure of the matrix in the gray iron section of the castings are presented in Fig. 8.

DISCUSSION

The experiments performed in this investigation have shown that differences in superheating temperature, pouring temperature and melting stock definitely affect the chill behavior of melts with almost identical chemical composition. Furthermore, if the results of the vacuum fusion analyses are considered to be valid, the changes in chill behavior produced by superheating temperature and pouring temperature do not appear to be related to changes in total oxygen, nitrogen or even perhaps hydrogen content.

This evidence would thus seem to refute the gas content theory which links the effects of superheating to the influences of different gases on graphitization. However, it must be considered that a customary gas analysis does not differentiate between the amount of gas present in uncombined form and that present in the form of compounds (oxides, etc.); and perhaps it is premature to discredit entirely the gas content theory.

In the investigation dealing with the influences of charge materials, an interesting comparison resulted when the amount of carbon present as graphite in each charge was calculated. These determinations indicated that the melts produced from the charges with the smaller amount of graphite (those prepared from roll scrap and graphite) exhibited less chill capacity than those produced from charges with a greater amount of graphite (melts produced from roll iron and pig iron).

This conclusion is not in agreement with the results of previous investigations, which indicate that greater amounts of graphite in the melting stock should decrease the chilling tendency of the subsequent melts.[8-9] At first consideration, the latter observations would seem to substantiate the graphite nuclei theory, while those of the current investigation appear to disprove it.

Research work carried out at The Pennsylvania

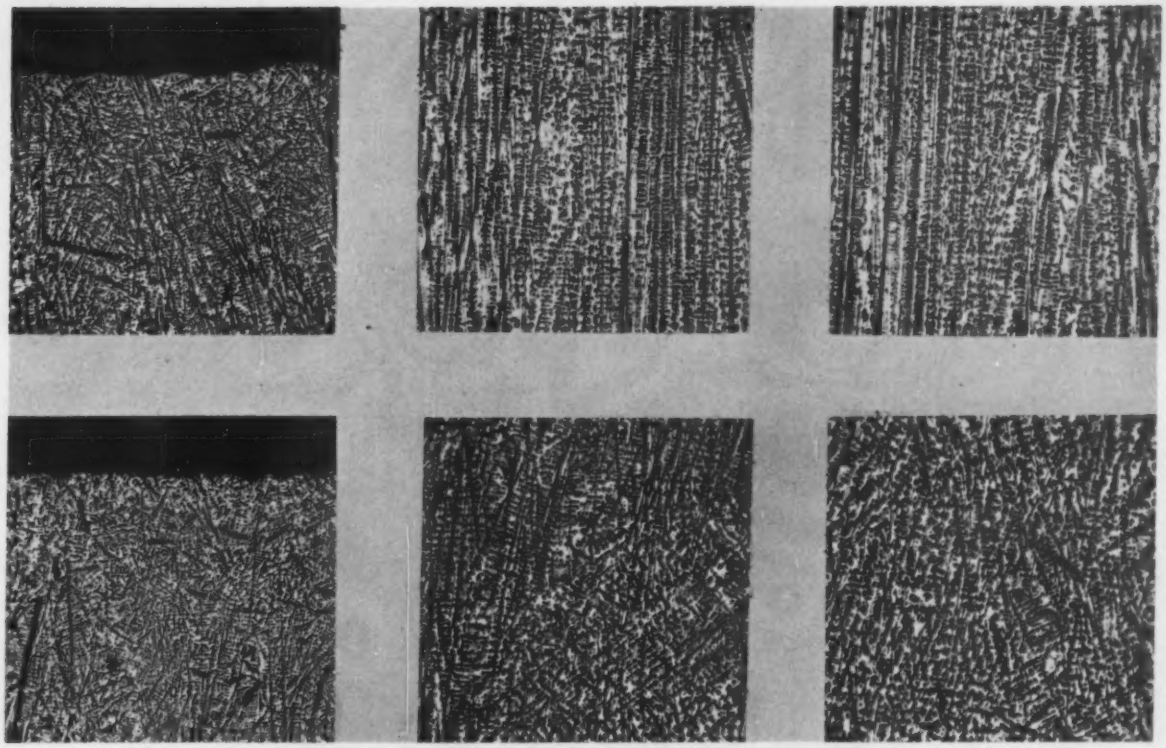

Fig. 7 — Microstructure of chill test castings at specified distances from surface of chill. *Top row* — superheating temperature — 2900 F; pouring temperature — 2900 F. *Bottom row* — superheating temperature — 2900 F; pouring temperature — 2450 F. Left to right — adjacent to chill, ¼-in. from chill and ½-in. from chill. 4 per cent nital etch. 25 ×.

State University, however, has shown that cast iron can graphitize to a considerable extent upon heating to its melting temperature.[10] It would appear necessary, therefore, to ascertain the amount of graphite present in the charge not at room temperature, but at the temperature of melting. Unfortunately, this was not done in the current experiments, and no firm conclusions regarding the validity of the graphite nuclei theory can be made.

Superheating Temperature Effect

Superheating temperature was shown to have no marked effect on the character of microconstituents in the white iron structure or in the gray iron structure of the chill test castings, providing pouring temperature was held constant. It should be pointed out, however, that superheating temperature does have an effect if a specific location in a casting, and hence a specific cooling rate, is considered.

Increased superheating temperature can, for instance, cause the structure of a casting at a certain location to become white or mottled depending on the temperature to which the melt is heated. It follows then, that increased superheating temperature can influence the structure of a casting by reducing the rate of cooling required to change the eutectic solidification from gray to white.

CONCLUSIONS

An increase in superheating temperature from 2600 to 2900 F (1427 to 1593 C) increases the carbide stability of roll-type cast iron.

The carbide stabilizing effects of superheating temperature are not a direct result of differences in customary chemical composition between melts superheated to different temperatures. Furthermore, they do not appear to be caused by differences in oxygen, nitrogen and perhaps hydrogen content.

Superheating temperature did not markedly affect the character of the microconstituents in the white iron and gray iron structures of the chill test castings. This observation should not be construed as evidence, however, that superheating has no effect on the overall structure of a casting.

The chill capacity of roll-type cast iron decreases as pouring temperature is reduced from superheating temperatures above 2600 F (1427 C).

The influence of pouring temperature on chill behavior is not the direct result of differences in customary chemical composition. This may also be true of differences in oxygen, nitrogen and hydrogen content.

Pouring temperature had a marked effect on the structure of the white iron in chill test castings produced from roll-type cast iron. The chill structure in

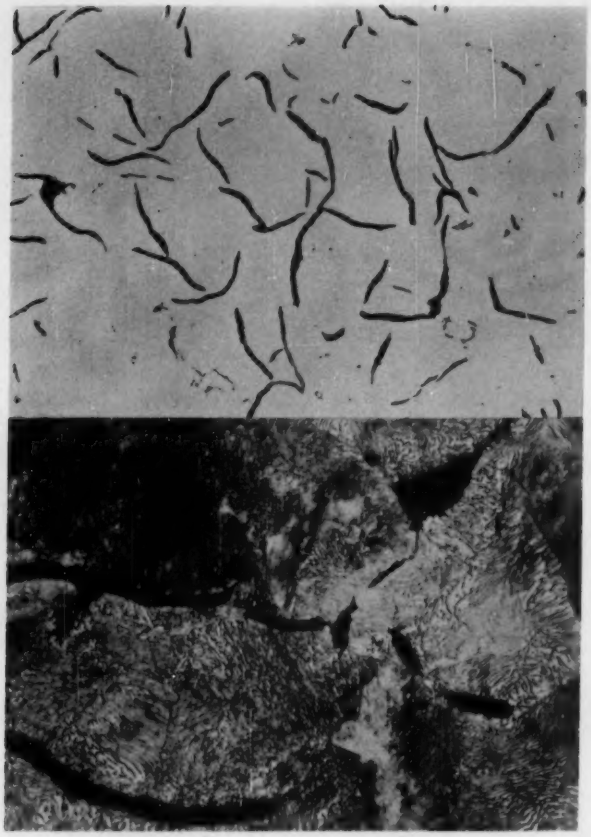

Fig. 8 — Typical microstructures of gray iron portion of chill test castings at a location 5 in. from chilled face. *Top* — unetched. 100 ×. *Bottom* — 4 per cent nital etch. 500 ×.

castings poured at 2450 F (1343 C) was considerably less columnar than that in castings poured from the same melt at the superheating temperature.

Charge materials noticeably affect the chill behavior of the subsequent melts. The changes become smaller, however, as the superheating temperature is increased from 2600 to 2900 F (1427 to 1593 C). Differences produced by charge materials evidently are not the result of differences in customary chemical composition.

ACKNOWLEDGMENTS

The authors wish to acknowledge the assistance of the Roll Manufacturers Institute which sponsored this investigation. Appreciation is also expressed to the Hyde Park Foundry and Machine Co. for supplying the roll iron, to the Mackintosh-Hemphill Div. of E. W. Bliss Co. for performing the chemical analyses and to the Allegheny-Ludlum Steel Corp. for furnishing the vacuum fusion gas analyses.

(This paper is Contribution No. 60-23 of the College of Mineral Industries, The Pennsylvania State University, University Park.)

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SYSTEMATIC APPROACH TO SAND DESIGN AND CONTROL

Progress report 2— clay bonded sand dry properties

by A. H. Zrimsek and G. J. Vingas

ABSTRACT

The second in a series of reports presenting basic data which describe the effect of a number of variables on foundry sands, this report deals with the dry properties of clay-sand-water combinations. The data presented compliment that given in the previous progress report. The systems covered in this report are those of western and southern bentonite and fireclay.

EXPERIMENT

The base sand used in the initial phases of this work is a 51.3 fineness Portage silica, a description of which is given in the table. As in the previous progress report,* data collected were obtained from sands mulled in an 18 in. laboratory muller. With this muller a batch size of 4000 grams of sand was used. To the dry sand was added the clay additions of 4.75, 7.45 or 10 per cent for the bentonites and 10 or 15 per cent for fireclay. A 15 sec dry mull preceded water additions.

To study the effect of mulling time on the development of dry properties, 2, 4 and 6 min wet mull cycles were used. The mulled sand was kept in airtight polyethylene bags while dry strength specimens were made at 1, 3, 5, 7 and 10 rams. Specimens were oven dried at 220-230 F for periods not less than 5 hr. At least five different water contents were used for each clay per cent at each mulling time.

RESULTS

Because the volume of data collected in this series of reports are large, results are shown in graphical rather than tabular form. The graphical presentation (Figs. 1-12) also allows a clear picture of trends which develop as variables are changed.

SCREEN ANALYSIS OF BASE SAND USED

U.S. Standard Sieve No.	Retained, %
20	0.0
30	2.6
40	19.3
50	30.1
70	24.4
100	15.1
140	5.6
200	2.4
Pan	0.6

DISCUSSION

As in the previous progress report, mulling time emerges as one of the major variables encountered. The effect of mulling time on physical properties in some instances overshadows the effects of clay type and per cent. The supposed low dry strength of southern bentonite versus the high dry strength of western does not appear in any of the data gathered from sands prepared in the 18 in. muller at mulling periods of 6 min or less. Dry strengths obtained with southern are in fact higher than those obtained with western in most instances.

The data so contradict the accepted precept, that western bentonite imparts higher dry strengths than southern, that checks were made on several other commercially available western and southern bentonites with similar results encountered. Western bentonites as a group followed closely the characteristics shown in Figs. 4 and 5, and southerns as a group followed the trends shown in Figs. 7 through 9. In no instance did the western bentonites impart significantly higher dry strengths than southern when mulled in the 18 in. laboratory muller.

Only when extensive mulling periods were used did the western surpass the southern. Use of the more efficient 12 in. laboratory muller allowed develop-

*A. H. Zrimsek and G. J. Vingas, "Systematic Approach to Sand Design and Control," AFS TRANSACTIONS, *vol. 68*, p. 440 (1960).

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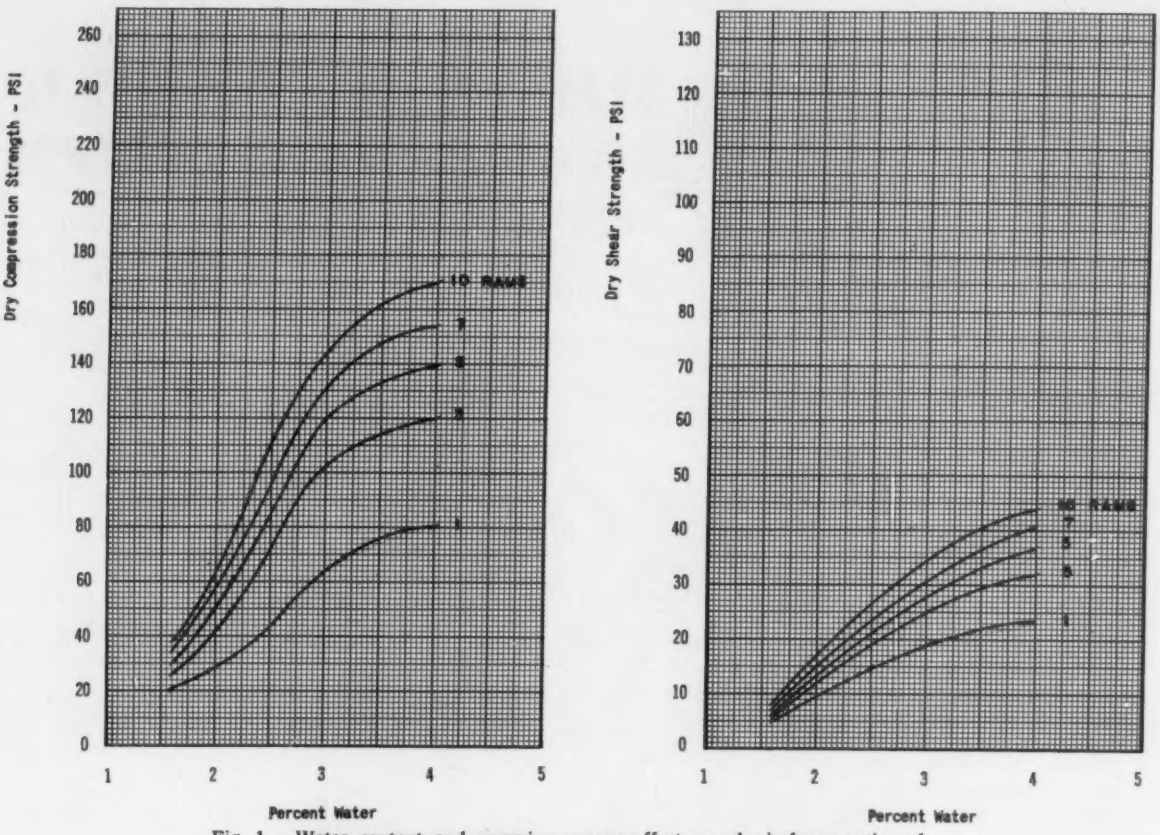

Fig. 1 — Water content and ramming energy effect on physical properties of 4.75 per cent western bentonite bonded Portage silica sand. Mulled 6 min.

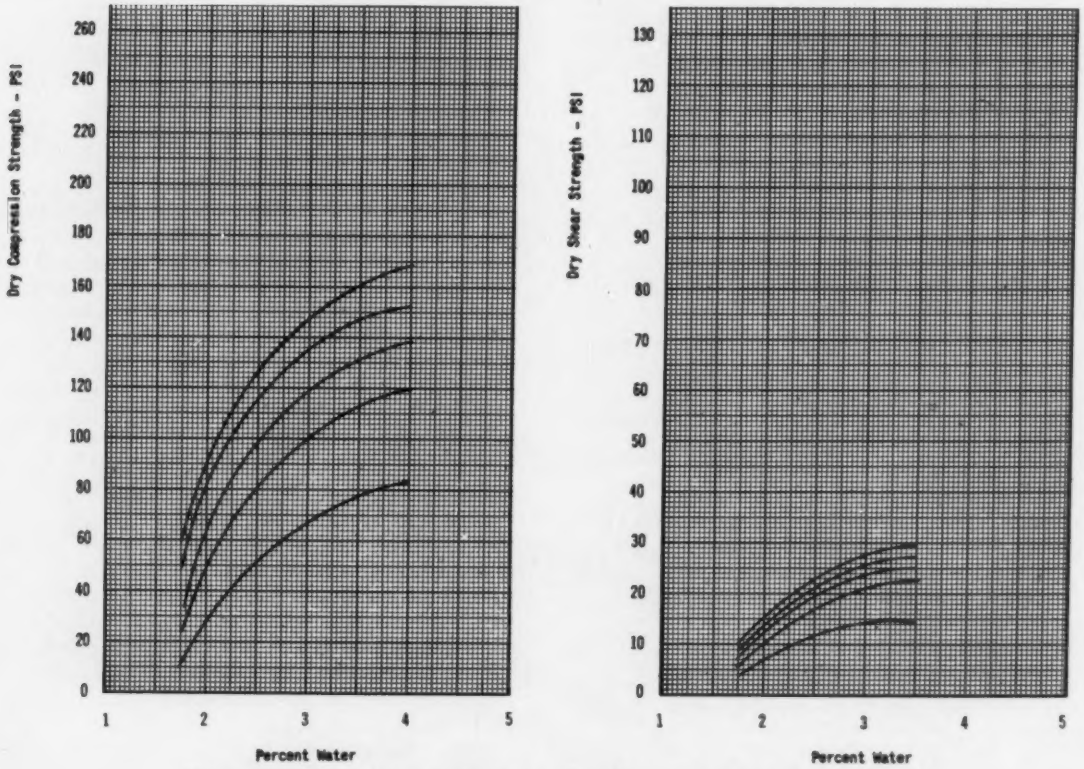

Fig. 2 — Water content and ramming energy effect on physical properties of 4.75 per cent southern bentonite bonded Portage silica sand. Mulled 6 min.

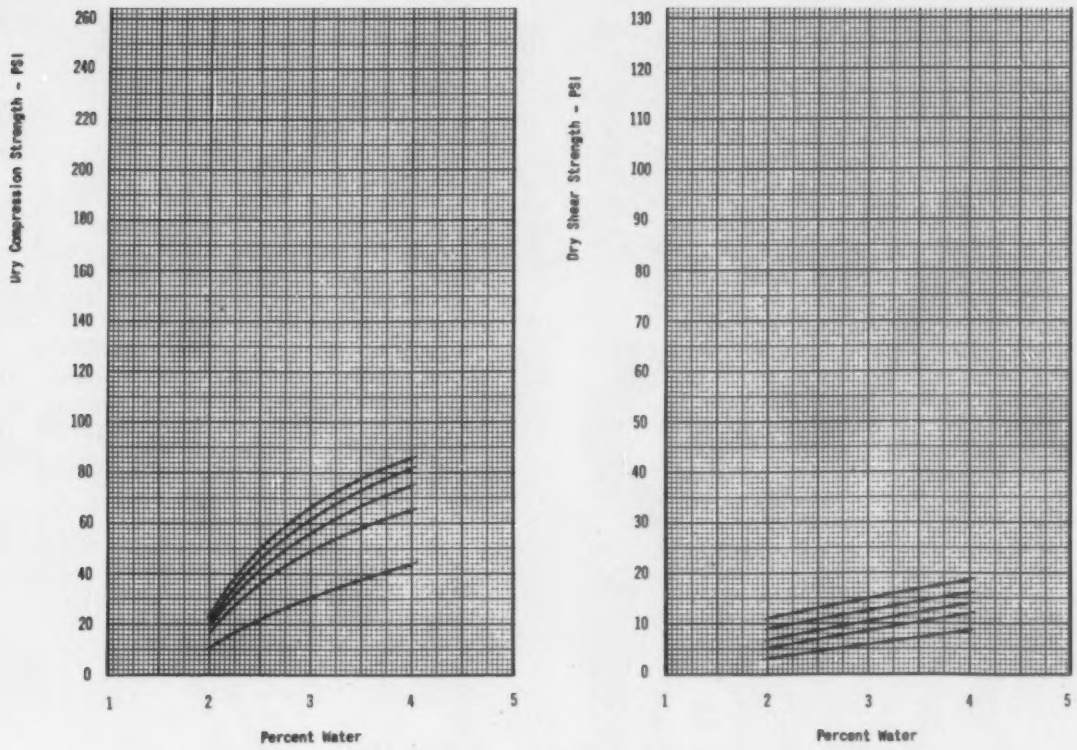

Fig. 3 — Water content and ramming energy effect on physical properties of 10 per cent fireclay bonded Portage silica sand. Mulled 6 min.

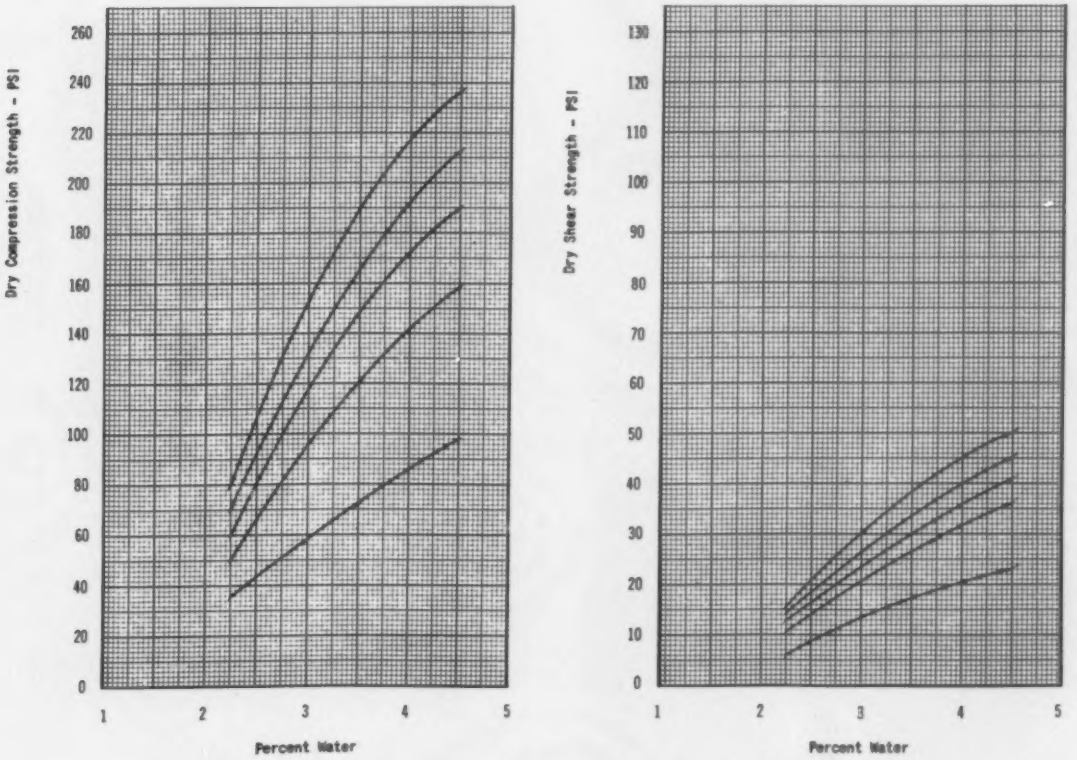

Fig. 4 — Water content and ramming energy effect on physical properties of 7.45 per cent western bentonite bonded Portage silica sand. Mulled 6 min.

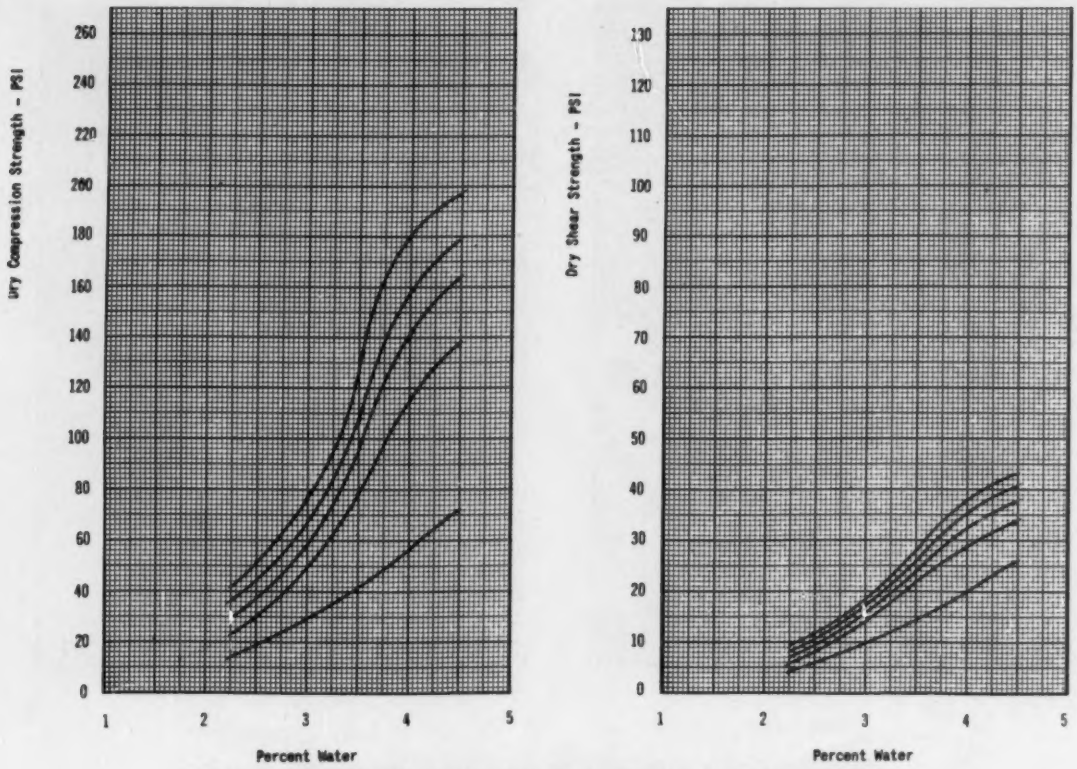

Fig. 5 — Water content and ramming energy effect on physical properties of 7.45 per cent western bentonite bonded Portage silica sand. Mulled 4 min.

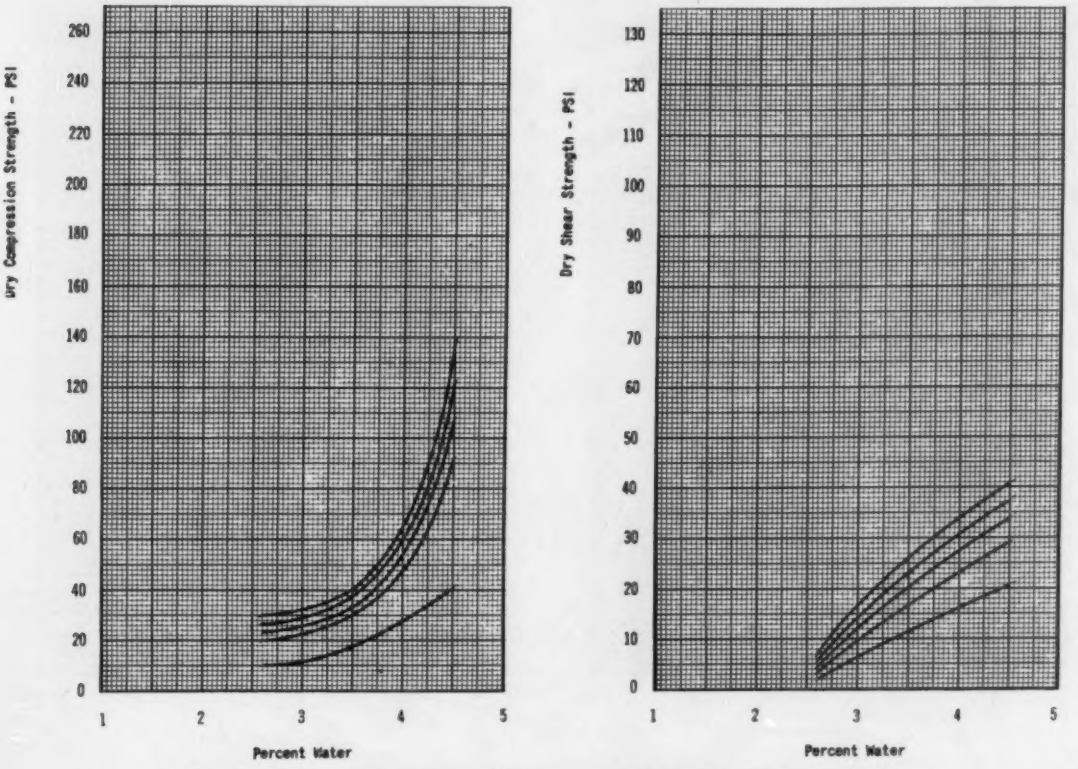

Fig. 6 — Water content and ramming energy effect on physical properties of 7.45 per cent western bentonite bonded Portage silica sand. Mulled 2 min.

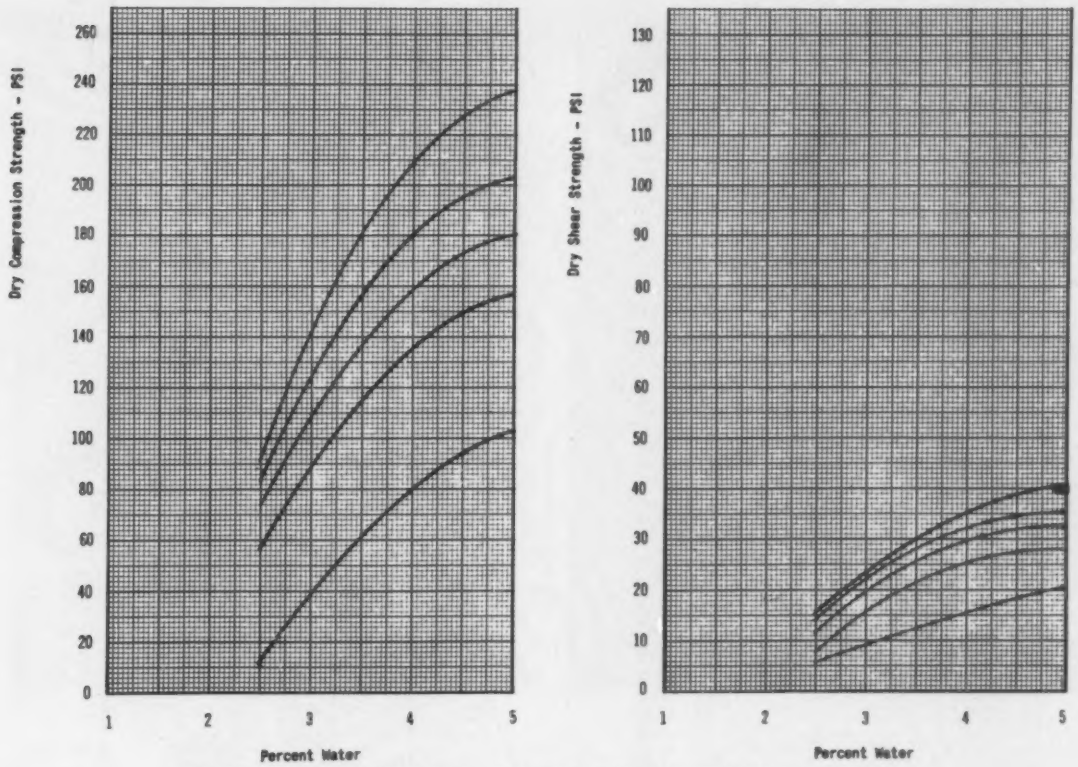

Fig. 7 — Water content and ramming energy effect on physical properties of 7.45 per cent southern bentonite bonded Portage silica sand. Mulled 6 min.

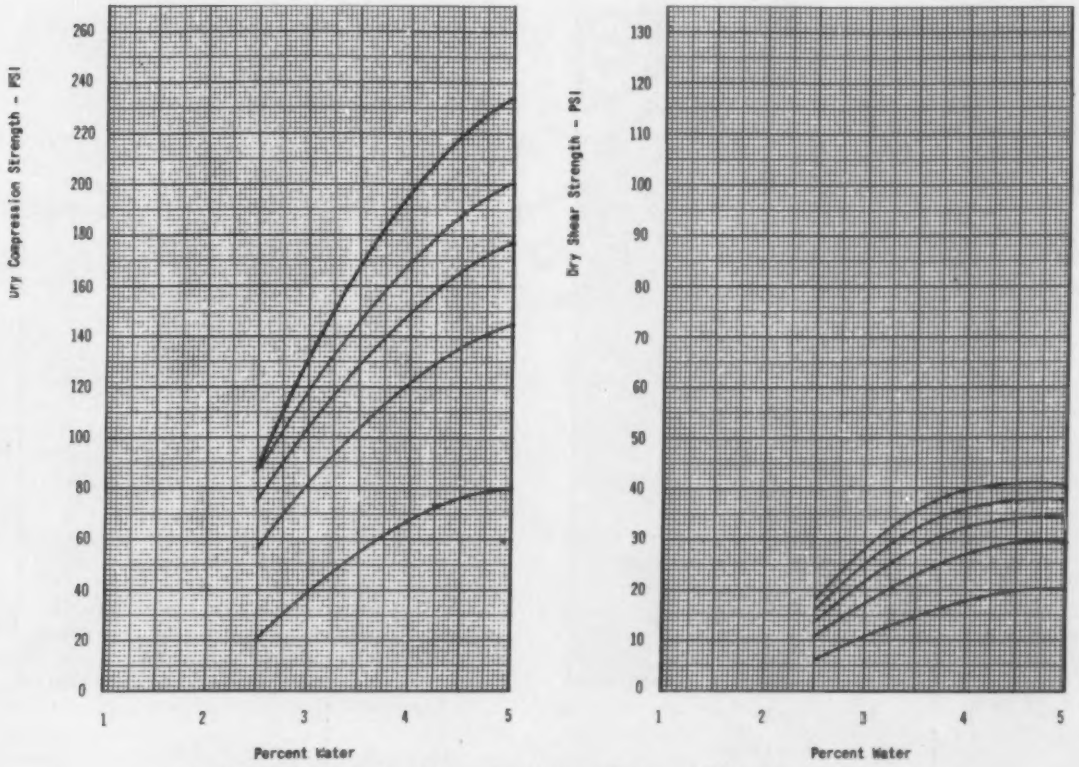

Fig. 8 — Water content and ramming energy effect on physical properties of 7.45 per cent southern bentonite bonded Portage silica sand. Mulled 4 min.

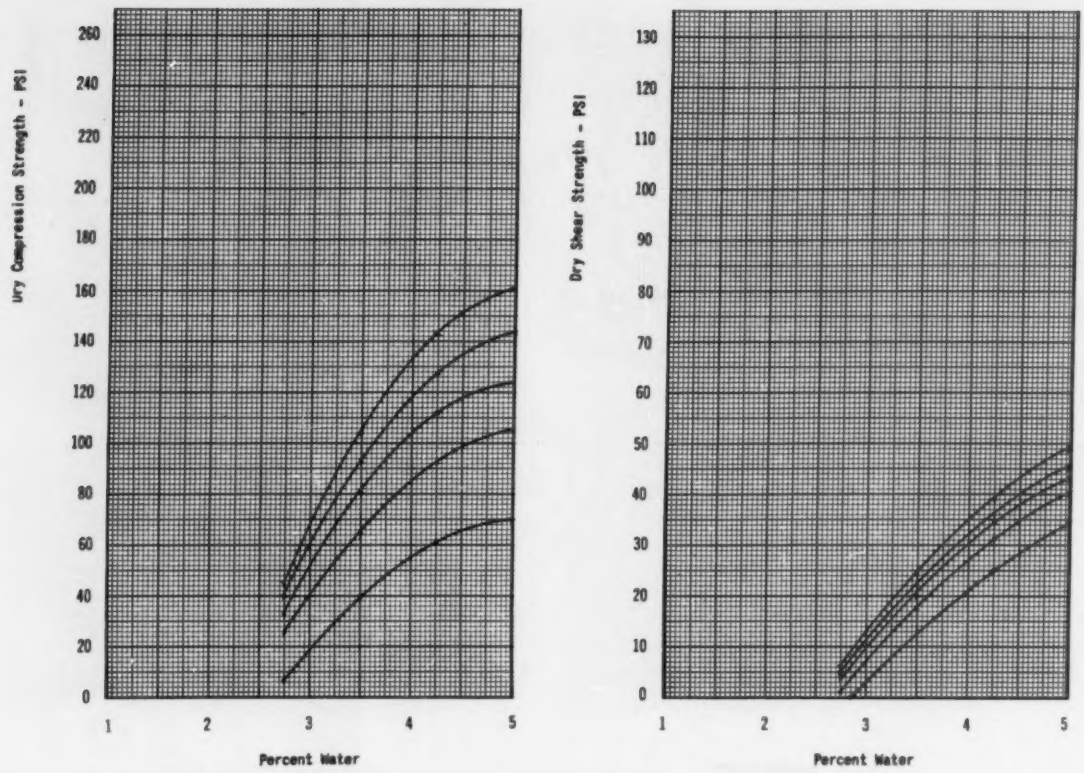

Fig. 9 — Water content and ramming energy effect on physical properties of 7.45 per cent southern bentonite bonded Portage silica sand. Mulled 2 min.

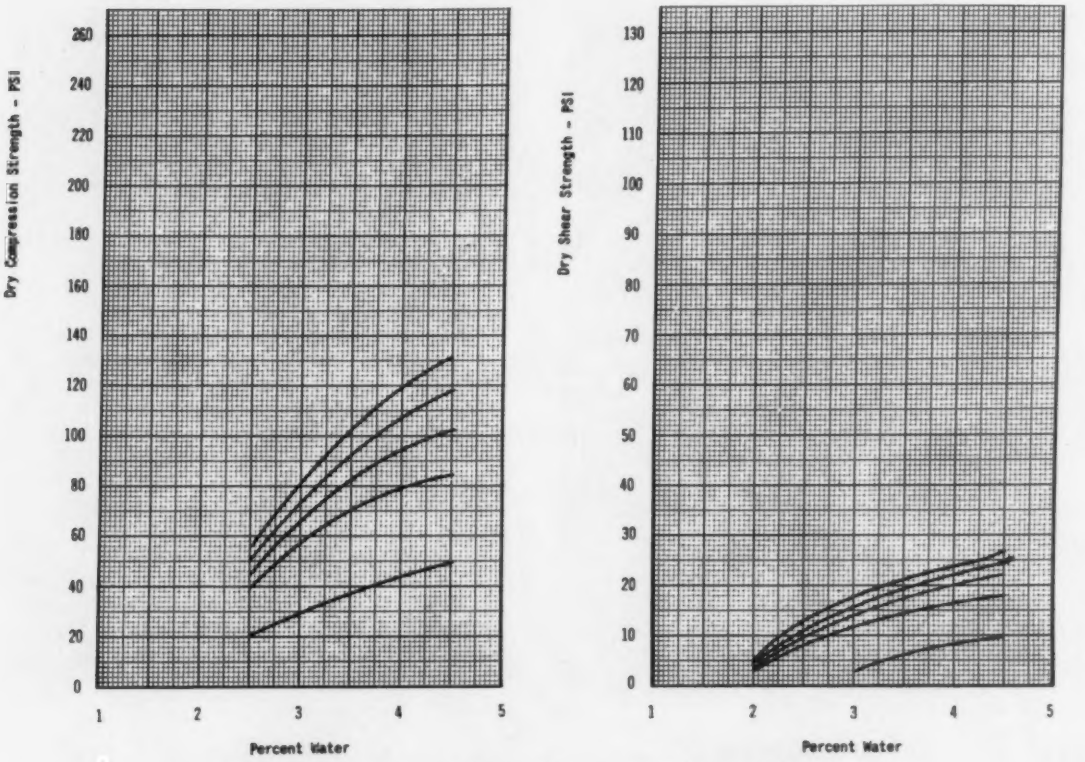

Fig. 10 — Water content and ramming energy effect on physical properties of 15 per cent fireclay bonded Portage silica sand. Mulled 6 min.

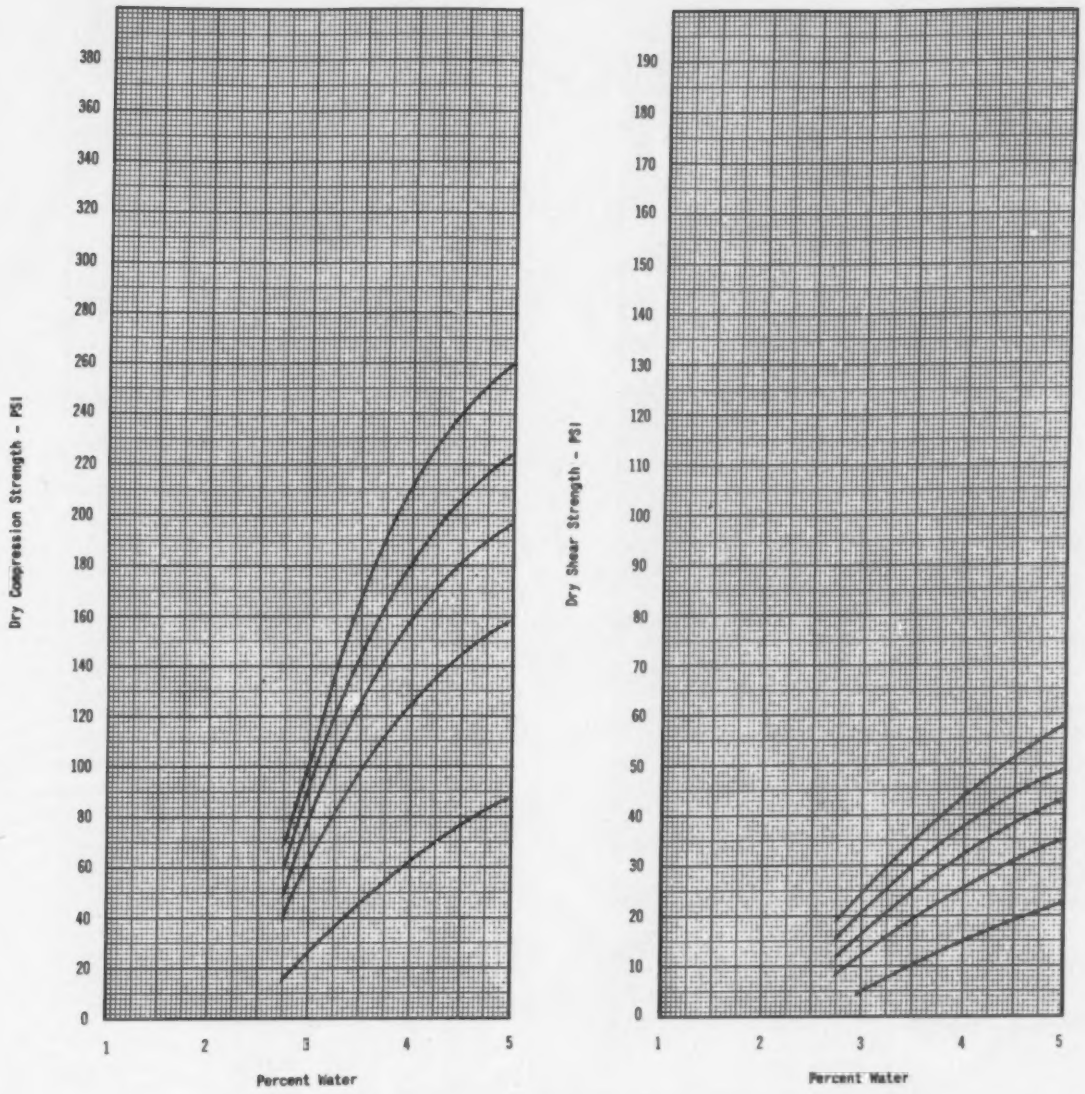

Fig. 11 — Water content and ramming energy effect on physical properties of 10 per cent western bentonite bonded Portage silica sand. Mulled 6 min.

ment of the maximum dry properties of western in only 6 min. As shown in comparing Figs. 11 and 12, western has the capability of imparting higher dry properties than southern, provided extensive or efficient mulling conditions exist.

The importance of mulling conditions as a variable is of much greater importance when using western bentonite than when using southern. This is true at least when new sand mixtures are being considered. Whether this holds true for rework sands remains to be seen, and will be covered in a later report of this series. The present data dealing with new mixtures would indicate that approximately two to three times as much mulling energy is required to develop the maximum properties of western than is required for southern. The mulling effect is in fact such an important factor in foundry sand design and control that an entire progress report of this series will be devoted to this important variable.

Dry properties of simple clay-sand-water systems are sensitive to small changes in water content. Regardless of clay type or per cent, increase in water is accompanied by an increase in dry strength. As pointed out earlier, the higher dry compression strength usually attributed to western over southern bentonite was not readily apparent. The dry shear strengths of western bentonite sands were, however, significantly higher than those bonded with southern.

Both dry compression and dry shear strengths ob-

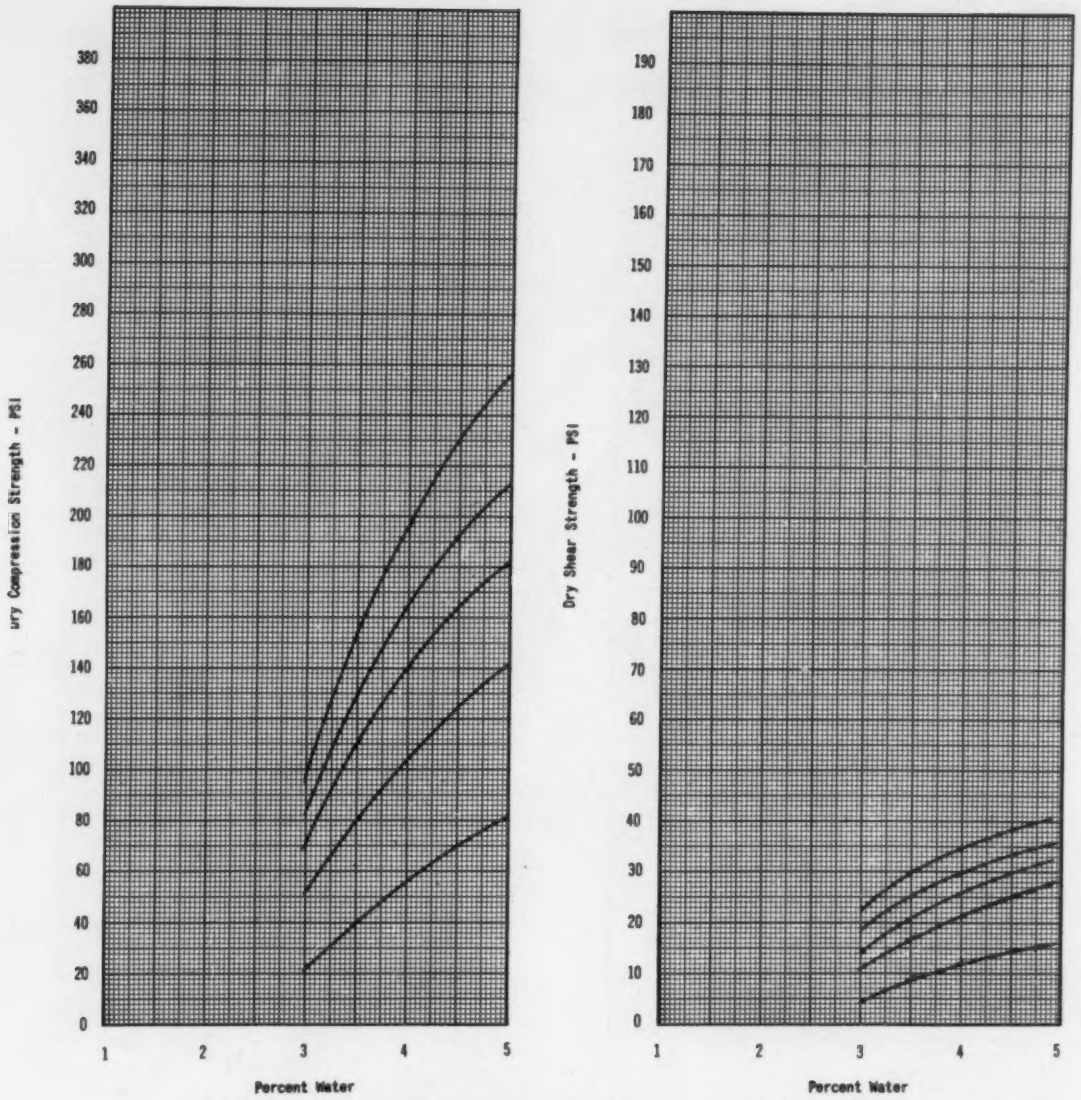

Fig. 12 — Water content and ramming energy effect on physical properties of 10 per cent southern bentonite bonded Portage silica sand. Mulled 6 min.

tained with fireclay bonded sands were much lower than obtained with western or southern bentonite.

CONCLUSIONS

Intelligent discussion of the physical properties of clay bonded sands is impossible without a thorough understanding of the function of mulling as a variable. It is apparent from the data thus far presented in this report and in the previous progress report that almost any combination of physical properties can be had through a variation in clay and water contents and mulling efficiency. The tremendous variation in physical properties possible through variations in mulling alone helps explain why sand formulations which work wonders in one foundry often cause chaos when tried in another.

There can be no doubt that the properties of clay bonded sands are affected extensively by mulling. Under the mulling conditions considered in this paper, there was little apparent difference in the dry properties of western and southern bentonite. Under no circumstances did the dry properties of fireclay approach those of either southern or western bentonite.

ACKNOWLEDGMENT

The writers wish to thank Magnet Cove Barium Corp. for permission to conduct these research activities and report the findings in published form.

MALLEABLE IRON GRAPHITIZATION KINETICS

Some trace elements influence

by G. Sandoz, B. F. Brown and W. A. Pennington

ABSTRACT

Trace amounts of the elements bismuth, antimony, tin, lead, cadmium and zinc were studied for their effects on the kinetics of each of the three graphitization reactions critical to the malleabilization of irons. The intrinsic affects of the elements were revealed with the use of formulas to correct for the nodule number differences between irons (differences in the number of graphite nodules per unit volume of iron). The effects of the trace elements were determined in irons with both low and high Mn-S ratios in order to detect possible interactions with sulfur.

The results show that some of the trace elements react with sulfur in irons with low Mn-S ratios and others do not. These affects are explained on the basis of thermodynamic estimates of the relative potentials of the trace elements to combine with sulfur in competition with iron. The trace elements do not form sulfides in irons with high Mn-S ratios, and in such irons the trace elements are all mildly retarding to graphitization rates.

INTRODUCTION

The rates of the graphitization processes that must take place during the malleabilization of white irons are sensitive to the composition of the iron. Accordingly, the concentrations of the major constituents, C, Si, Mn, S and P are closely controlled. However, a number of elements may be acquired adventitiously in small or trace amounts over which close control is impractical, and some of these are suspected of severely retarding graphitization rates. For example, the elements present in white metal, bushings, liners, etc., which may constitute a fraction of the scrap used in melting, are often held accountable for annealing difficulties encountered with irons of normal base composition.

Nevertheless, the data reported in the literature in support of such claims are meager, mostly qualitative and in some cases contradictory. Accordingly, an investigation was conducted with the aim of determining quantitatively the effects of controlled small amounts of elements Bi, Sb, Sn, Pb, Cd and Zn on the graphitization processes in irons—irons synthetically prepared, but close enough to commercial malleable compositions that the influences of impurity elements should be similar.

GENERAL BACKGROUND

An evaluation of the effects of alloying elements on the graphitization of malleable irons requires that the effects be identified with respect to each of the three individual graphitization reactions which take place and are necessary to malleabilization. These reactions may be summarized as follows:

First Stage:	Cementite	→	Austenite + Graphite
Second Stage:	Austenite	→	Ferrite + Graphite (direct)
	Pearlite	→	Ferrite + Graphite (indirect)

As indicated, there are two main divisions into which the reactions fall, first and second stage graphitization. First stage graphitization involves one reaction—the conversion of eutectic cementite into austenite and graphite. Second stage graphitization involves two reactions, either or both of which may convert the material entirely into ferrite and graphite.

As an iron is cooled slowly through the critical temperature range and into subcritical regions, the austenite begins to transform directly into ferrite and graphite. However, before this reaction is completed, a part of the austenite may transform into an intermediate pearlite. This pearlite may itself decompose into ferrite and graphite at subcritical temperatures.

Since alloying elements may influence the rates differently, and thereby the relative participation of these reactions, it is clearly necessary to relate data on the effects of alloying elements to the specific reaction involved. In this paper, distinction between the two second-stage reactions will be made by the terms "direct" and "indirect."

Another important requirement to any evaluation of the effects of alloying elements on the graphitiza-

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(This paper is based on a Thesis submitted by G. Sandoz in partial fulfillment of the requirements for the PhD degree at the University of Maryland.)

tion kinetics of malleable irons is that the effects be identified with respect to the nucleation and growth features of each reaction. It is desirable to know whether an alloying element influences the rate of a particular reaction primarily by increasing or decreasing the number of graphite nodules per unit volume of iron developed during graphitization, or whether an intrinsic change in the graphitization processes such as relative thermodynamic stability of the carbide phase is involved.

A practical benefit of such information would be the possibility of predicting whether heat treatment—prequenching, for example—would be of help in malleablizing a contaminated lot of castings. Only castings contaminated with elements that act primarily through nodule number reduction would be expected to benefit from such treatment.

Finally, the effects of alloying elements should be identified as either direct influences on the processes limiting graphitization rates or as secondary effects resulting from chemical combination with other elements in the iron, particularly sulfur.

In searching the literature describing the effects of the trace elements, an attempt was made to evaluate the data in terms of the above considerations.

LITERATURE REVIEW

Schwartz and Guiler[1] examined the effects of ladle additions of ½ to 1 per cent (amount added) of a large variety of alloying elements to malleable irons of "normal composition." All irons were put through the complete regular malleable annealing cycle, and subsequently fracture appearance and microstructure were examined to detect any retarding elements.

They found no overall retarding effects from the elements Pb, Bi, Zn and Cb. However, Sn and Sb were found to retard overall graphitization. Sn had about the same effect as Cr, and over 0.07 per cent was considered enough to make the iron completely unmalleablizable. There is no way of determining from this work, of course, the retarding influence on the individual graphitization reactions.

Palmer[2] investigated the graphitization behavior of three blackheart malleable irons, one containing 0.06 per cent Sb, the second 0.025 per cent Bi and the third 0.016 per cent Sn. Graphitization was measured by microscopic examination and by combined and graphitic carbon determinations. However, interpretation of the results is difficult because Palmer's irons were severely decarburized during first stage graphitization. In the second stage, samples of the irons were cooled at a rate of 3 C/hr and pulled out and quenched at various temperatures. Since the graphitization of pearlite is relatively slow, the results may be considered to apply primarily to the direct second stage reaction.

All of the three elements studied by Palmer, particularly Bi, retarded first stage graphitization to some extent. Much of the observed retarding action, however, was confined to the final traces of cementite. The bulk of the cementite graphitized nearly as readily as in the base iron.

In the second stage, 0.06 per cent Sb produced severe retarding of graphitization. A cooling rate of 3 C/hr almost completely suppressed ferrite formation. The presence of 0.025 per cent Bi, or 0.16 per cent Sn also retarded second stage graphitization but to a lesser extent, for substantial amounts of bullseye ferrite were present in each case (the unalloyed base iron was completely ferritic). At least part of the retarding effects in the irons containing Sn and Sb can be attributed to decreased nodule number, because this effect definitely is exhibited in the microstructures.

Sn, Pb and Sb Influence

Shnay, Wilson and Rehder[3] have reported on the influence of trace amounts of Sn, Pb and Sb on first and direct second stage reaction rates. Time to complete first stage graphitization was determined microscopically, and second stage effects were followed by measuring the amounts of ferrite and pearlite in the microstructure resulting from various linear cooling rates. The effects of the three elements on the graphitization rate of pearlite were not determined. No attempt was made to measure nodule size and number.

These investigators found no effects on first stage graphitization rates caused by the presence of up to 0.011 per cent Sb, 0.029 per cent Pb or 0.046 per cent Sn. The element Pb also had no effect on the direct second stage reaction. The elements Sn and Sb, however, appeared to accelerate the direct second stage reaction in amounts up to 0.014 per cent and 0.003 per cent, respectively. Greater amounts of these elements produced a declining rate. The decline of graphitization rate as Sn was increased to 0.046 per cent. It was, however, mild, and certainly not indicative that 0.07 per cent Sn should make the iron completely unmalleablizable.[1,4]

In other work, Rehder[5] has ascribed difficulties in producing commercial blackheart malleable iron to the presence of 0.09 per cent Sn. In this case, however, the difficulties appear to be caused by retarded graphitization of pearlite in the second stage as much as with retarded direct second stage graphitization, and not at all with first stage graphitization.

Several investigations of the influence of Sn on gray and ductile irons are pertinent to the effect of Sn on the second stage graphitization of malleable irons. David, Krause and Lownie[6] have reported that the addition of up to 0.10 per cent Sn is beneficial in gray iron because of the suppression of ferrite formation.

They also have reported that Sn suppresses bullseye ferrite in ductile irons. This is supported by DeSy and Foulon,[7] who have reported that as little as 0.03 per cent Sn can prevent all ferrite formation in ductile irons normally 70 to 90 per cent ferritic. Gilbert and Palmer[8] have prevented ferrite formation in a normally 50 per cent ferritic ductile iron by adding 0.059 per cent Sn. It seems well accepted, therefore, that the presence of Sn in these materials retards the direct graphitization of austenite in the second stage.

LITERATURE EVALUATION

The available data in the literature indicate that the elements Pb, Cd and Zn are without effects on the rates of any of the three graphitization reactions, although only the data on Pb[3] may be considered quantitative. The best data available indicate that the

TABLE 1 — CHEMICAL COMPOSITIONS OF TRACE ELEMENT SERIES (WT. PER CENT)

Heat No.	C	Si	Mn	S	P	Ni	Bi	Sb	Sn	Pb	Cd	Zn
H—100—A*	1.90	1.10	0.04	0.03	0.01	—	—	—	—	—	—	—
H—100—J	1.90	1.10	0.04	0.03	0.01	—	0.056	—	—	—	—	—
H—100—I	1.90	1.10	0.04	0.03	0.01	—	0.090	—	—	—	—	—
H—116—A*	2.15	0.95	0.02	0.02	0.01	—	—	—	—	—	—	—
H—116—D	2.15	0.95	0.02	0.02	0.01	—	—	—	—	0.003	—	—
H—116—C	2.15	0.95	0.02	0.02	0.01	—	—	—	—	0.021	—	—
H—116—B	2.15	0.95	0.02	0.02	0.01	—	—	—	—	0.038	—	—
H—116—G	2.15	0.95	0.02	0.02	0.01	—	—	—	0.021	—	—	—
H—116—F	2.15	0.95	0.02	0.02	0.01	—	—	—	0.067	—	—	—
H—116—E	2.15	0.95	0.02	0.02	0.01	—	—	—	0.081	—	—	—
H—116—J	2.15	0.95	0.02	0.02	0.01	—	—	0.010	—	—	—	—
H—116—I	2.15	0.95	0.02	0.02	0.01	—	—	0.037	—	—	—	—
H—116—H	2.15	0.95	0.02	0.02	0.01	—	—	0.055	—	—	—	—
H—116—L	2.15	0.95	0.02	0.02	0.01	—	—	—	—	—	—	0.017
H—120—A*	2.10	0.95	0.04	0.03	0.01	—	—	—	—	—	—	—
H—120—C	2.10	0.95	0.04	0.03	0.01	—	—	—	—	—	—	0.003
H—120—B	2.10	0.95	0.04	0.03	0.01	—	—	—	—	—	—	0.022
H—128—A*	2.20	0.91	0.04	0.03	0.01	—	—	—	—	—	—	—
H—128—F	2.20	0.91	0.04	0.03	0.01	—	—	—	—	—	0.002	—
H—128—E	2.20	0.91	0.04	0.03	0.01	—	—	—	—	—	0.003	—
L—56—A*	2.20	0.80	0.14	0.02	0.01	—	—	—	—	—	—	—
L—56—D	2.20	0.80	0.14	0.02	0.01	—	—	—	—	0.023	—	—
L—56—E	2.20	0.80	0.14	0.02	0.01	—	—	—	0.045	—	—	—
L—56—F	2.20	0.80	0.14	0.02	0.01	—	—	0.083	—	—	—	—
L—56—G	2.20	0.80	0.14	0.02	0.01	—	0.083	—	—	—	—	—
L—56—H	2.20	0.80	0.14	0.02	0.01	—	—	—	—	—	0.002	—

* — Base Iron

elements Bi, Sb and Sn retard both the first stage and direct second stage graphitization reactions, except possibly when present in extremely small amounts. Some data indicate that Sn also retards the indirect second stage graphitization of pearlite. No pertinent data were found that describe the effects of Bi and Sb on the graphitization of pearlite.

In general, the investigations described in the literature have been confined to irons containing substantially greater amounts of Mn than of S. Possible interactions between trace elements and S have therefore been little considered. Moreover, there have been few attempts to measure and correlate the effects of trace elements with changes in graphite nodule number, and no attempt has been made to separate such effects from intrinsic effects.

It is evident that only qualitative estimates of the effects of most of the trace elements are available in the literature. More detailed information is needed, particularly if it is hoped to obtain clues as to the mechanisms involved. To summarize, the information which is required should provide:

1) Data on the intrinsic effects of the trace elements, i.e., those effects not associated with change of nodule number.
2) Data showing the effects of the trace elements on the process (course) of each graphitization reaction. For example, entire sigmoid first stage graphitization curves are needed, not just the times required to graphitize completely.
3) Data that permit clear distinction between the effects on the individual graphitization reactions.
4) Data on irons of both low and high Mn-S ratio in order to permit the detection of possible interactions between the trace elements and sulfur.

The experiments described in this paper were undertaken with the aim of obtaining this information.

MATERIALS PREPARATION

All of the irons were prepared from armco iron, 50 per cent ferro-silicon, Mexican graphite and, where required, 80 per cent Mn ferro-manganese. All trace-element additions were made with chemically pure stock stirred into the ladle during pouring. Melting was done in a 300 lb basic induction furnace fitted with a cover. A helium atmosphere was maintained over the charge except during pouring. All melts were poured at 2750 F (1510 C) after holding in the furnace for 30 min. All series were cast as split heats in order to minimize the effects of melting variables.

All irons were cast into open finger molds fed by a large runner. The molds were made of synthetic steel facing sand. Fingers (⅜ x 1 x 5 in.) of these castings were broken off and sliced into ¼-in. thick specimens for graphitization studies. Preliminary studies showed graphitization rates to be uniform throughout the fingers except for regions near the runner and near the extreme ends; hence no specimens were taken from areas less than 1¼-in. from each end of individual fingers. Table 1 gives the analyses of the heats prepared.*

Procedures for Measuring Graphitization Rates

First stage graphitization was followed by measuring quantitatively the amounts of graphite formed in specimens heated to 1650 F (899 C) for various times. The specimens were heated in a tube furnace in an

*Analyses of the trace elements were done by Crippen and Erlich Laboratories Inc., Baltimore, Md.

atmosphere of helium which had been passed through drierite and hot copper turnings. Time was measured after the specimens first reached 1650 F (899 C) which took about 15 min. All specimens were water quenched at the end of the selected graphitization period.

The amount of graphite (and therefrom the per cent graphitization) of the specimens was measured by use of the point counting method of quantitative metallography. A series of experiments indicated that this method was more reproducible than attempting to measure a quantity of cementite, because of the presence of many fine spheroidal carbides throughout the austenite of most irons, particularly at the beginning of graphitization. Point counting was performed over an area of 0.3 sq mm at 500 ×, and a minimum of 1000 grid intersections were examined for each measurement. Independent checks with different samples established that measurements were reproducible within ±5 per cent graphitization.

Second Stage Graphitization

Direct second stage graphitization was investigated by measuring quantitatively the amounts of pearlite formed in specimens as a function of linear cooling rate from 1650 F (899 C) (after first stage graphitization was complete). This is a legitimate procedure because any austenite that is not eliminated by the direct second stage reaction transforms to pearlite; hence the proportion of pearlite remaining in the matrix after the linear cool through the critical temperature range is inversely proportional to the amount of direct second stage graphitization that has occurred.

Some of the pearlite that forms, of course, begins to graphitize by the indirect second stage reaction, but this reaction is relatively slow and generally takes place by a "fading out" of the pearlite that does not involve a recession of the original boundaries. Graphitization of the pearlite was minimized by quenching the samples in water after they had reached 1200 F (643 C); this quench served further to assure that all possible direct second stage graphitization representative of a given cooling rate had taken place, as evidenced by the absence of any martensite (from untransformed austenite).

After a sample had been cooled in a helium atmosphere at a selected cooling rate, the point counting method was used to measure the amount of pearlite in the matrix. An area of 1.8 sq mm was examined at 200 ×, involving observations of at least 1000 grid intersections. Differences between measurements were 5 per cent of pearlite or less, when measured by two individuals.

It was found possible to reduce the number of individual specimens required to measure direct second stage graphitization by simply reaustenitizing one specimen as many times as needed to check each cooling rate. Several checks indicated the procedure was valid provided a specimen was held in helium at the reaustenitizing temperature of 1650 F (899 C) for at least 2 hr. Rehder and Wilson[9] have published data indicating that repeated annealing of one specimen increases direct second stage graphitization rates, but their reaustenitizing times of only 15 min and their use of a less neutral atmosphere probably account for their observations.

Indirect second stage graphitization was measured by following the rate of decrease of combined carbon of pearlitic specimens held at 1200 F (643 C) in helium. A series of specimens was obtained for each determination by air cooling from 1650 F (899 C) after first stage graphitization was complete. One specimen was retained as a base so that the combined carbon content at the beginning of the reaction could be determined; the others were reheated to 1200 F (643 C) for selected periods and then quenched in water. Slugs for combined-carbon analysis were cut out of the center of each specimen to eliminate any difficulty from surface effects.

*Nodule Number Normalization**

In order to separate the intrinsic effects of the trace elements from their indirect effects caused by a changing of the nodule number (number of nodules/cu mm of iron) developed during graphitization, use was made of empirical expressions developed and reported on previously.[10] These expressions were derived from observations that in both first stage and direct second stage graphitization the changes in the log of reaction rates are linear with respect to the log of nodule number. The indirect second stage graphitization of pearlite is so insensitive to nodule number as to make normalization unnecessary.

Several symbols were adopted:

T_F is the time to a given level of first stage graphitization, say 50 per cent.

T_{FN} is the time T_F that would have been observed had the nodule number remained constant after addition of an alloying element.

In all cases comparisons are made with a base iron, the original fraction of a split heat.

In the direct second stage reaction the term R_C was adopted to indicate the linear cooling rate to give a certain percentage of pearlite in an iron, usually 50 per cent. The term R_{CN}, then, indicates the cooling rate that would have yielded 50 per cent pearlite had the addition of an alloying element not changed the nodule number of the base iron. The expressions developed are:

First Stage Reaction

$$T_{FN(alloy)} = T_{F(alloy)} - T_{F(base)} \left[\left(\frac{N_{V(base)}}{N_{V(alloy)}} \right)^{0.29} - 1 \right]$$

Second Stage Reaction

$$R_{CN(alloy)} = R_{C(alloy)} - R_{C(base)} \left[\left(\frac{N_{V(alloy)}}{N_{V(base)}} \right)^{0.45} - 1 \right]$$

The number of nodules/cu mm of iron, N_v, was obtained by counting the number of nodules observed (at 200 ×) within one sq mm of a polished cross-section of sample. Conversion from nodules/unit area to nodules/unit volume was done with the formula from Saltykov:[11]

$$N_V = 2.38\ N_A^{1.6}$$

*The term "normalization" is used throughout this paper in its mathematical sense and does not relate to the metallurgical heat treatment process.

where

N_V = nodules/cu mm.
N_A = nodules/sq mm.

Both expressions for normalizing nodule number differences between base and alloy iron heats are applicable to any specific level of graphitization. The nodule number values used in the formula for the first stage graphitization reaction should be measured at the level of graphitization at which T_{FN} is determined. However, experience has shown that little error is introduced if the nodule number be measured at some other level.[10] For example, the nodule numbers measured after 100 per cent graphitization may be used when determining T_{FN} at the 50 per cent level, and this was done in this paper.

The nodule numbers used in the formula for the direct second stage reaction are the same as those measured after 100 per cent first stage graphitization, provided the iron is held at the first stage graphitization temperature sufficiently long to minimize coarsening effects. Experience has shown that nodule number remains constant during direct second stage graphitization.[10]

RESULTS

Because of space limitations, complete first and direct second stage graphitization curves will be given only for the element bismuth; for the other elements only the 50 per cent levels of graphitization will be considered. Complete graphitization curves of the other elements were obtained, however, and are generally available.[10] The results will be reported according to individual elements except for the indirect second stage reaction where the results will be presented collectively.

Bismuth

Studies of the effects of Bi on first stage and direct second stage graphitization were conducted on two series of irons, one with an Mn-S ratio of 1.3, the other with an Mn-S ratio of 7.0. Figures 1 and 2 give the complete graphitization curves of the low Mn-S ratio series, Figs. 3 and 4 of the high Mn-S ratio series. Table 2 presents the data obtained at the 50 per cent levels of graphitization only.

It is seen that both reactions are retarded by the presence of Bi, regardless of the Mn-S ratio of the iron. The L-56-G iron, containing 0.083 per cent Bi showed a tendency for a few carbides to persist near the end of the first stage reaction. Figure 5 shows some of these persistent carbides.

Although such small amounts of carbide probably would have little influence on the properties of the iron, they may well account for statements in the literature that Bi severely retards the reaction, because some investigators have based measurements of the effects of trace elements on the time to eliminate carbide completely from the microstructure. Several of the other trace elements (Sb, Sn, Pb, Cd) were observed to develop a small amount of persistent carbides near the end of first stage graphitization, but there was never any effect on the graphitization curve until graphitization was about 95 per cent complete.

The graphitization rate values normalized for nodule number variation at the 50 per cent levels of

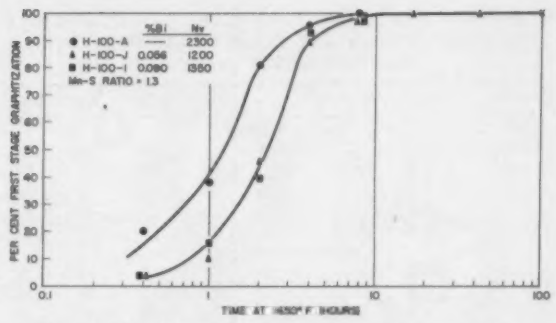


Fig. 1 — Bi effect on first stage graphitization of low Mn-S ratio irons.

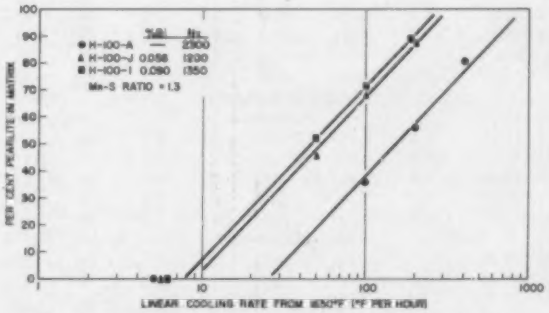

PER CENT PEARLITE IN MATRIX
LINEAR COOLING RATE FROM 1650°F (°F PER HOUR)
H-100-A — 2300
H-100-J 0.056 1200
H-100-I 0.080 1350
Mn-S RATIO = 1.3

Fig. 2 — Bi effect on direct second stage graphitization in low Mn-S ratio irons.

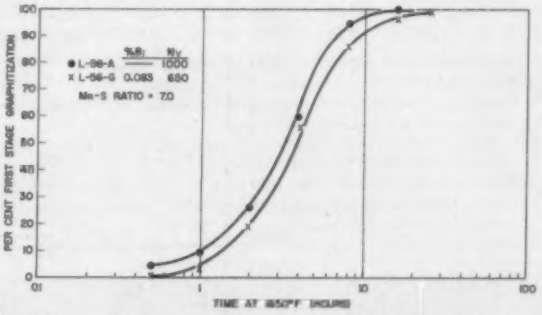


Fig. 3 — Bi effect on first stage graphitization of high Mn-S ratio irons.

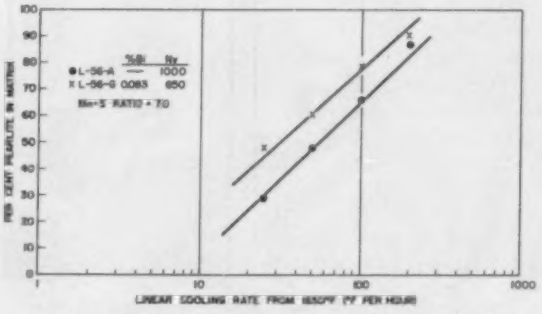


Fig. 4 — Bi effect on direct second stage graphitization of high Mn-S ratio irons.

TABLE 2 — TRACE AMOUNTS OF ELEMENTS EFFECT ON FIRST STAGE AND DIRECT SECOND STAGE GRAPHITIZATION KINETICS

Heat. No.	Mn/S	Bi, %	N_V[1]	T_F[2]	T_{FN}[3]	R_C[4]	R_{CN}[5]
Bismuth Series							
H-100-A	1.3	—	2300	1.2	1.2	150	150
H-100-J	1.3	0.056	1200	1.9	1.6	54	94
H-100-I	1.3	0.090	1350	1.9	1.65	46	76
L-56-A	7.0	—	1000	3.4	3.4	54	54
L-56-G	7.0	0.083	650	4.0	3.7	32	41
Antimony Series							
H-116-A	1.0	—	1550	3.7	3.7	34	34
H-116-J	1.0	0.010	1900	4.0	4.2	36	33
H-116-I	1.0	0.037	1700	4.0	4.1	25	24
H-116-H	1.0	0.055	1650	4.2	4.1	21	20
L-56-A	7.0	—	1000	3.4	3.4	54	54
L-56-F	7.0	0.083	900	4.0	3.8	21	27
Tin Series							
H-116-A	1.0	—	1550	~3.7	3.7	34	34
H-116-G	1.0	0.021	1850	~3.7	3.9	72	69
H-116-F	1.0	0.067	1850	~3.7	3.9	66	63
H-116-E	1.0	0.081	1150	~3.7	3.6	56	59
L-56-A	7.0	—	1000	3.4	3.4	54	54
L-56-E	7.0	0.045	650	4.2	3.5	30	39
Lead Series							
H-116-A	1.0	—	1550	~3.7	3.7	34	34
H-116-D	1.0	0.003	1550	~3.7	3.7	68	68
H-116-C	1.0	0.021	1850	~3.7	3.5	76	73
H-116-B	1.0	0.038	1400	~3.7	3.8	50	51
L-56-A	7.0	—	1000	3.4	3.4	54	54
L-56-D	7.0	0.023	540	4.2	3.5	35	47
Cadmium Series							
H-128-A	1.3	—	3900	3.3	3.3	36	36
H-128-F	1.3	0.002	3550	3.7	3.5	45	47
H-128-E	1.3	0.003	2000	4.2	3.5	45	55
L-56-A	7.0	—	1000	3.4	3.4	54	54
L-56-H	7.0	0.002	550	4.3	3.5	25	37
Zinc Series							
H-116-A	1.0	—	1550	~3.7	3.7	34	34
H-116-L	1.0	0.017	1450	~3.7	3.6	67	68
H-120-A	1.3	—	4600	~3.3	3.3	45	45
H-120-B	1.3	0.003	3950	~3.3	3.2	61	65
H-120-C	1.3	0.022	3100	~3.3	3.0	92	100

(1) Nodules/cu mm after 100% first stage graphitization.
(2) Time in hr for 50% first stage graphitization.
(3) Time in hr for 50% first stage graphitization after normalization for nodule number differences.
(4) Cooling rate in deg. Fahr./hr to give 50% pearlite during direct second stage graphitization.
(5) Cooling rate in deg. Fahr./hr to give 50% pearlite during direct second stage graphitization after normalization for nodule number differences.

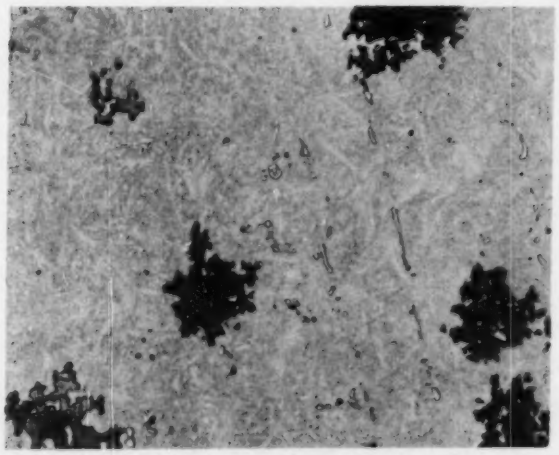


Fig. 5 — Persistent carbides in iron containing Bi near end of first stage graphitization reaction (L-56-G). 200 ×.

graphitization (T_{FN} and R_{CN}) are given in Table 2, and are plotted in Figs. 6 and 7. It is seen that Bi retards intrinsically both first stage and direct second stage graphitization in irons with low and high Mn-S ratios. The effect of adjusting for nodule number is to make the retarding effects appear less severe. This is because Bi, along with several other of the trace elements, tends to reduce nodule number, a retarding influence in itself.

Antimony

The two series of irons used to investigate the effects of antimony on the first stage and direct second stage reactions had Mn-S ratios of 1.0 and 7.0. The data obtained at the 50 per cent levels of graphitization are given in Table 2. Observing the changes in T_F and R_C with increasing Sb, it is seen that Sb slows the first stage and direct second stage reactions slightly, regardless of the Mn-S ratio of the iron. The one exception was the iron containing 0.01 per cent antimony (H-116-J) which graphitized slightly faster in direct second stage than did the base iron.

The 50 per cent graphitization rate values of the two series of irons normalized for nodule number variations are plotted in Figs. 8 and 9. It is immediately evident that the fast overall direct second stage graphitization of the H-116-J iron is accounted for by the fact that this iron developed a higher nodule number than did the base iron (H-116-A) probably because of some uncontrolled variable during melting and solidification. The normalized 50 per cent values plotted in Figs. 8 and 9 show that Sb acts similarly to Bi and retards both reactions intrinsically, whatever the Mn-S ratio of the iron.

Tin

The two series of irons used to evaluate the effects of Sn on first stage and direct second stage graphitization were of Mn-S ratio 1.0 and 7.0. As indicated in Table 2, there was little effect of Sn on the first

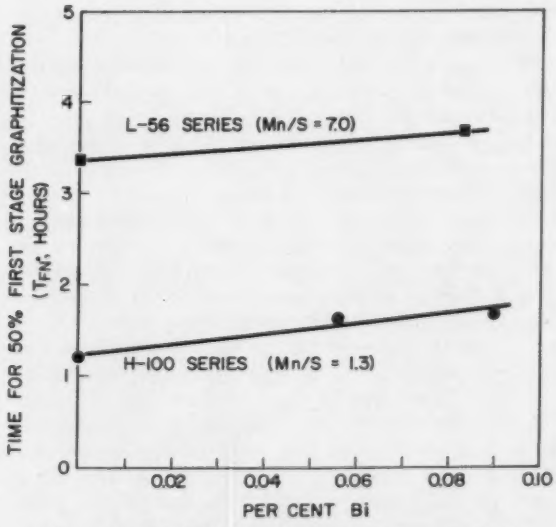


Fig. 6 — Intrinsic effects of Bi on first stage graphitization in irons of low and high Mn-S ratio.

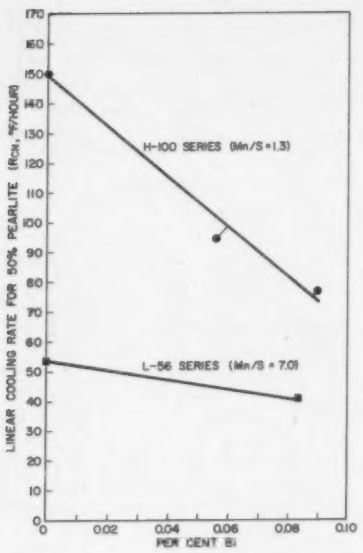


Fig. 7 — (left) Intrinsic effects of Bi on second stage graphitization in irons of low and high Mn-S ratio.

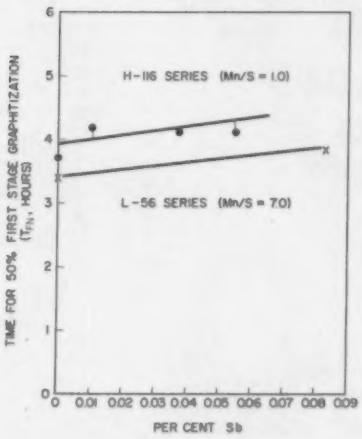


Fig. 8 — (right) Intrinsic effects of Sb on first stage graphitization of low and high Mn-S ratio irons.

stage graphitization rate in the series with the lower Mn-S ratio. On the direct second stage reaction, up to 0.02 per cent Sn increased the graphitization rate, but a gradual decrease followed as Sn was increased to 0.081 per cent. In the series with Mn-S ratio of 7.0, the presence of 0.045 per cent Sn decreased the rates of both the first stage and direct second stage reactions.

The 50 per cent values of graphitization normalized for nodule number variation are plotted in Figs. 10 and 11. Figure 10 shows that the intrinsic effects of Sn are negligible on first stage graphitization if the Mn-S ratio of the iron is 1.0. However, when the Mn-S ratio is 7.0 Sn retards the reaction slightly. Figure 11 shows that the intrinsic effects of Sn on the direct second stage reaction are similar to the overall effects; up to 0.02 per cent Sn promotes the reaction in the irons of low Mn-S ratio, but greater amounts cause a progressive retardation.

The presence of Sn retards the reaction when the Mn-S ratio is 7.0. It would appear therefore that Sn may interact with S in irons with low Mn-S ratio and thereby speed up the reaction; once the reaction with S nears completion, greater amounts of Sn may cause retarding because the iron then behaves as if the Mn-S ratio of the iron were greater.

Lead

The results on Pb were almost identical with those on Sn, as may be seen in Table 2 and in Figs. 12 and 13.

Cadmium

Two series of irons with Mn-S ratios of 1.3 and 7.0 were used to study the effects of Cd on the first stage and direct second stage graphitization reactions. As shown in Table 2, the presence of Cd retards the first stage reaction slightly in both series of irons. On the direct second stage reaction, Cd speeds graphitization in the irons with low Mn-S ratio, but retards graphitization in the irons with high Mn-S ratio.

The intrinsic effects of Cd on first stage graphitization are small in irons with both low and high Mn-S ratio, as shown in Fig. 14. The intrinsic effects of Cd on the direct second stage reaction, however, are again to promote the reaction in low Mn-S ratio irons and retard in high Mn-S ratio irons, as in Fig. 15. Thus, Cd apparently interacts with S in irons with low Mn-S ratio, but not in irons with high Mn-S ratio, behaving similarly in Sn and Pb in this respect. Probably Cd would retard the direct second stage reaction in irons of low Mn-S ratio should it be present in amounts greater than needed to interact with

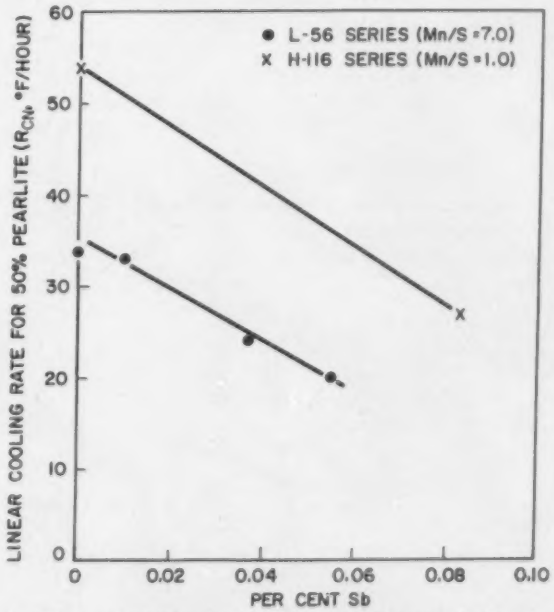


Fig. 9 — Intrinsic effects of Sb on direct second stage graphitization of low and high Mn-S ratio irons.

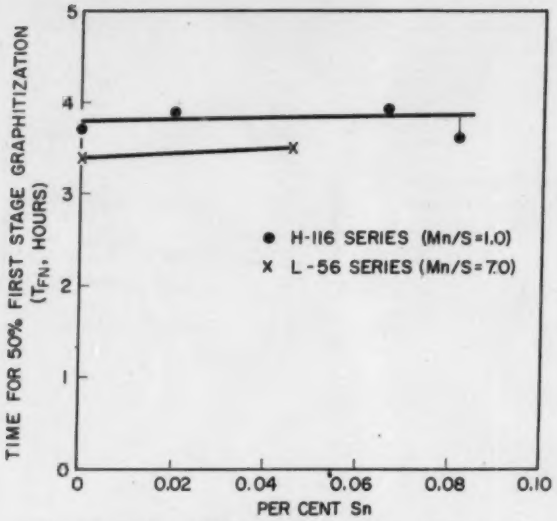


Fig. 10 — (above) Intrinsic effects of Sn on first stage graphitization of low and high Mn-S ratio irons.

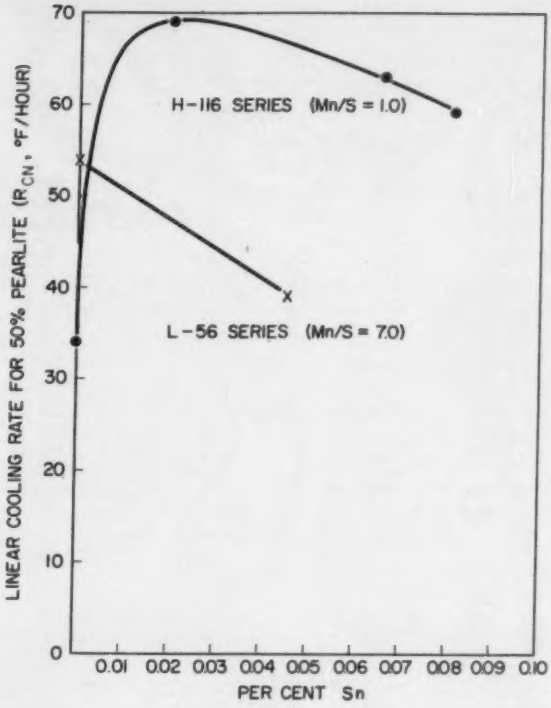


Fig. 11 — (right) Intrinsic effects of Sn on the direct second stage graphitization of low and high Mn-S ratio irons.

the excess S, similar to the characteristics of Sn and Pb.

Zinc

Investigations of the effects of Zn on the first stage and direct second stage graphitization reactions were limited to two series of irons with low Mn-S ratio (1.0 and 1.3). As shown in Table 2, there was no effect of Zn on the first stage graphitization rate of either series. On the direct second stage reaction, the presence of Zn speeded graphitization.

The intrinsic effect of Zn on the first stage graphitization reaction of irons with low Mn-S ratio are given in Fig. 16. A slight tendency for Zn to promote the reaction is indicated, but the effect is small and may not be significant. The presence of Zn does promote intrinsically the direct second stage reaction in these irons, however, as shown in Fig. 17. Thus, Zn is apparently another element that may interact with the S in irons with low Mn-S ratio.

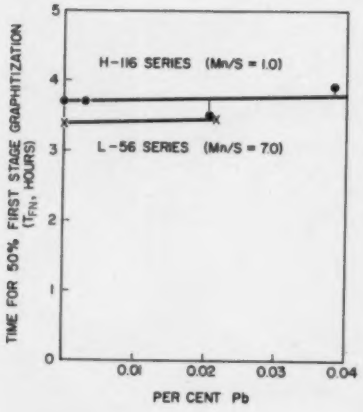
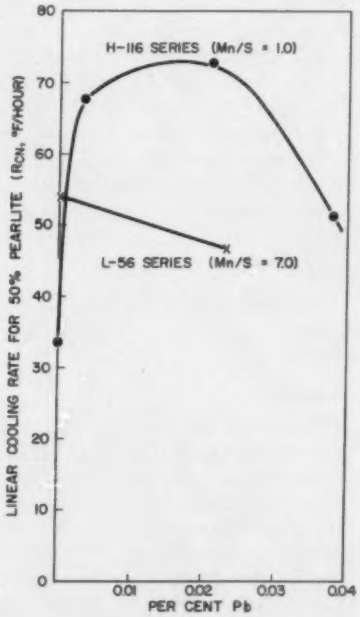


Fig. 12 — (left) Intrinsic effects of Pb on first stage graphitization of low and high Mn-S ratio irons.

Fig. 13 (right) Intrinsic effects of Pb on direct second stage graphitization of irons of low and high Mn-S ratio irons.



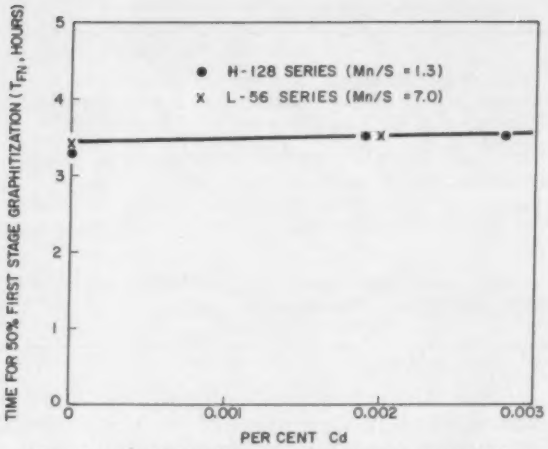


Fig. 14 — Intrinsic effects of Cd on first stage graphitization of irons of low and high Mn-S ratio irons.

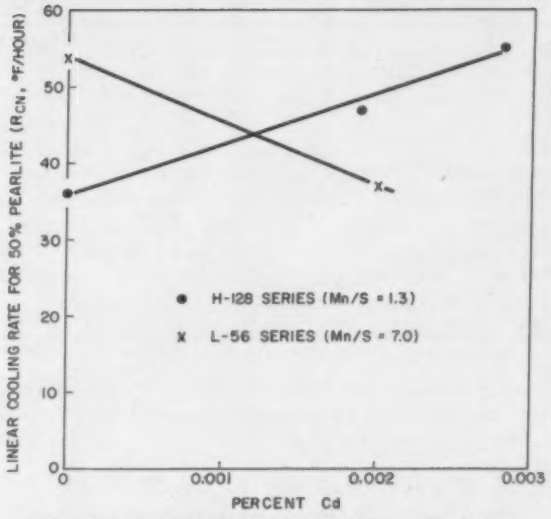


Fig. 15 — Intrinsic effects of Cd on direct second stage graphitization of low and high Mn-S ratio irons.

Indirect Second Stage Reaction

Studies of the effects of the trace elements on the indirect second stage reaction were limited to a series of irons prepared from a split heat and having an Mn-S ratio of 7.0. The results are plotted in Fig. 18, and show that trace amounts of the elements studied have little effect on the reaction in iron with high Mn-S ratio. Although no data were obtained on irons with low Mn-S ratio, the only possible effects that could appear therein would be some promoting action by interaction with S.

DISCUSSION OF RESULTS

The results of the trace element graphitization studies have been summarized in Table 3. For the first stage reaction, all of the trace elements either retard slightly or have no definite effects. In irons with low Mn-S ratio, where nodule number effects are not normalized, the elements Sn, Pb and Zn have no definite effects, Sb retards slightly and Bi and Cd slightly. Some of these results are accounted for by nucleation or nodule number effects. Thus, when the results are normalized for nodule number, the apparent retarding effect of Cd vanishes and that of Bi is less.

In irons with high Mn-S ratio, the elements Bi, Sb, Sn, Pb and Cd all show a slight retarding effect on first stage graphitization, although a substantial part of the retarding is caused by nodule number effects. In addition, all of the elements (Zn was not studied)

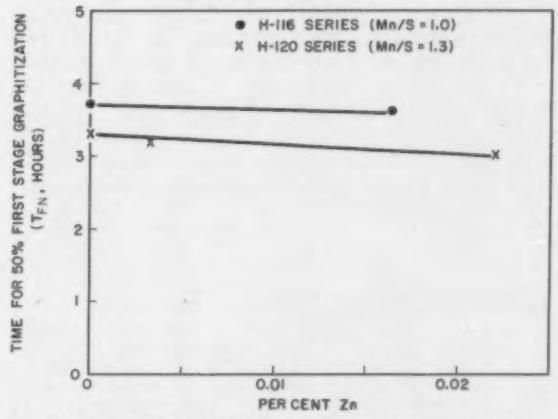


Fig. 16 — Intrinsic effects of Zn on first stage graphitization of low Mn-S ratio irons.

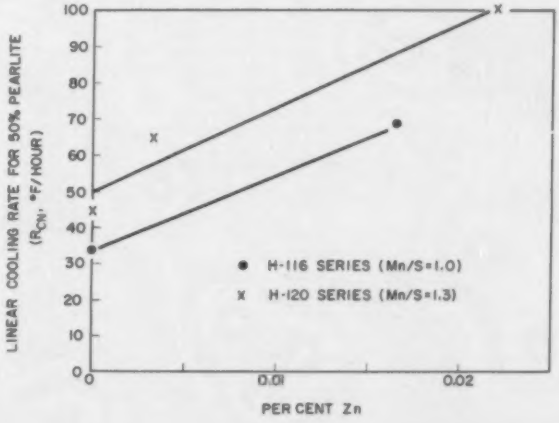


Fig. 17 — Intrinsic effects of Zn on direct second stage graphitization of low Mn-S ratio irons.

TABLE 3 — SUMMARY OF TRACE ELEMENTS EFFECTS

	Low Mn-S Ratio Irons		High Mn-S Ratio Irons	
	First Stage Reaction			
Effect	Not Normalized For Nodule Number	Normalized for Nodule Number	Not Normalized For Nodule Number	Normalized for Nodule Number
No Effect	Sn, Pb, Zn	Sn, Pb, Cd, Zn	—	—
Very slight retard	Sb	Bi, Sb	—	Bi, Sb, Sn, Pb, Cd
Slight retard	Bi, Cd	—	Bi, Sb, Sn, Pb, Cd	—
Persistent final traces of carbide	—	—	Bi, Sb, Sn, Pb, Cd	—
	Direct Second Stage Reaction			
Promote	Cd, Zn	Cd, Zn	—	—
Promote followed by retard	Sn, Pb, Sb	Sn, Pb	—	—
Retard	Bi	Bi, Sb	Bi, Sb, Sn, Pb, Cd	Bi, Sb, Sn, Pb, Cd
	Indirect Second Stage Reaction			
No effect	—	—	Bi, Sb, Sn, Pb, Cd	—

show a tendency for traces of carbide to persist near the completion of the reaction, but not in amounts likely to greatly influence the ductility of the material.

The effects of the trace elements are more pronounced on the direct second stage graphitization reaction. In irons with low Mn-S ratio, where nodule number differences are not normalized, the elements Cd and Zn promote graphitization, the elements Sn, Pb and Sb promote graphitization in small amounts but retard in larger amounts, and the element Bi retards in any amount. After normalizing these results for nodule number effects, it is seen that the promoting effects of Cd and Zn are intrinsic. The effects of Pb and Sn are also intrinsic in their characteristic of first accelerating and then retarding the reaction. However, Sb is seen to be an intrinsic retarder like Bi.

In irons with high Mn-S ratio the elements Bi, Sb, Sn, Pb and Cd all retard direct second stage graphitization. Although not indicated in Table 3, the retarding effects of these elements are in some degree attributable to nodule number effects.

Table 3 also indicates that the effects of Bi, Sb, Sn, Pb and Cd on the indirect second stage reaction are negligible in irons with high Mn-S ratio.

Trace Elements Potentials

The observations indicated in Table 3 are explainable in terms of the relative abilities of the trace elements to combine with S in competition with iron and manganese. The relative potentials of the trace elements in question to combine with sulfur bound as FeS may be estimated from published free energy of formation data.[12-15] Figure 19 shows schematically the results of such estimates. It is seen that the elements Bi and Sb would not be expected to remove much S from FeS whereas the elements Mn, Zn and Cd would; Pb and Sn are borderline cases. None of

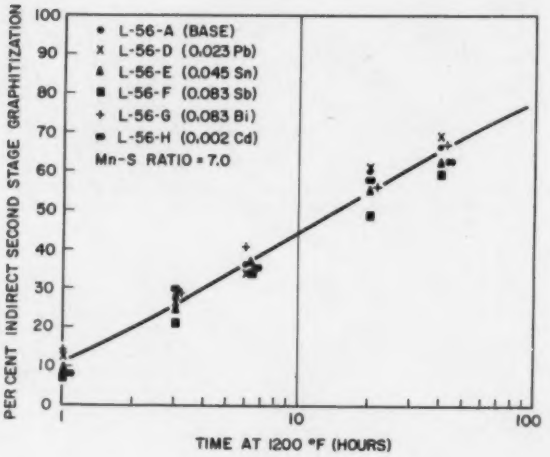


Fig. 18 — Pb, Sn, Sb, Bi and Cd effects on indirect second stage graphitization of pearlite in high Mn-S ratio irons.

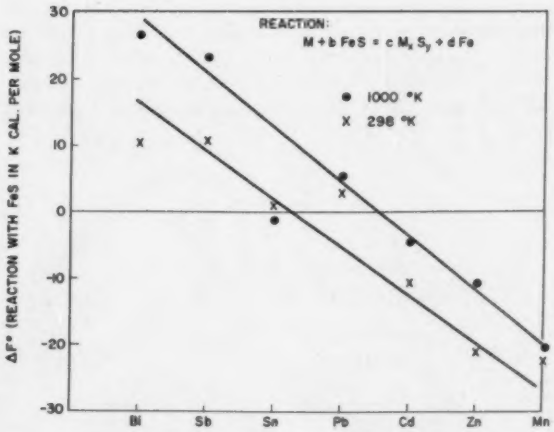


Fig. 19 — Schematic representation of relative free energy values for removal of S from FeS.

the trace elements would be expected to remove sulfur from MnS, however, for this is the most stable sulfide of the group.

It is evident, therefore, that the elements Bi and Sb would not be expected to accelerate graphitization rates by interactions with S in irons with low Mn-S ratio, whereas the elements Cd and Zn would probably do so. The elements Pb and Sn would be expected to interact with S to some extent. Referring again to Table 3, it is seen that this is the behavior observed experimentally. Thus, the elements Cd, Zn, Sn and Pb intrinsically promote the direct second stage reaction in irons with low Mn-S ratio, whereas the elements Bi and Sb retard.

The fact that the elements Sn and Pb also begin to retard the reaction as their amounts are increased is evidence that

a) these elements have rather low potential for combining with sulfur.
b) that the reactions with sulfur become essentially completed and thereafter the two elements act as if the iron were of higher Mn-S ratio.

The elements Cd and Zn would possibly also begin to retard the reaction if they were added in sufficient quantities.

The same general effects of the trace elements are observed on the first stage graphitization reaction in irons with low Mn-S ratio, but the effects are less pronounced. This is in accordance with the known less sensitivity of this reaction to the presence of excess sulfur.[16,17]

In irons with high Mn-S ratio none of the trace elements would be expected to interact with sulfur, for their potentials of combination with sulfur are all less than that of manganese. Thus, in irons with high Mn-S ratio the trace elements are free to manifest their intrinsic retarding effects. In such cases the intrinsic retarding actions observed may be associated with solution in and stabilization of cementite, or by influences on the relative pearlite and ferrite hardenabilities, as have been proposed elsewhere to explain the retarding effects of Mn and sulfur.[10]

SUMMARY AND CONCLUSIONS

The effects of trace amounts of the elements Bi, Sb, Sn, Pb, Cd and Zn on the three major graphitization reactions in malleable irons were investigated. Irons with both low and high Mn-S ratio were employed to show possible interactions of the trace elements with sulfur. Normalization of the results with respect to nodule number differences between irons was carried out in order that the intrinsic effects of the trace elements could be revealed. The main conclusions are:

1) The effects of the trace elements, Sn, Pb and Cd vary with the Mn-S ratio of the iron. The effects of Bi and Sb do not change with Mn-S ratio.
2) In irons with low Mn-S ratio the elements Sn, Pb, Cd and Zn have negligible intrinsic effects on first stage graphitization. The elements Bi and Sb retard slightly.
3) On the direct second stage reaction in irons with low Mn-S ratio, the elements Cd and Zn promote intrinsically, the elements Sn and Pb promote in small amounts but begin to retard in larger amounts and the elements Bi and Sb retard in all amounts. These effects are explainable in terms of the relative potentials of trace elements for combination with sulfur in the presence of iron.
4) In irons with high Mn-S ratio all of the trace elements (Zn was not studied) retard slightly both the first stage and direct second stage reactions. The retarding of the first stage reaction is greatest near the end of the reaction, suggesting that the effects of the trace elements are associated with cementite stability.
5) The trace elements have little influence on the indirect second stage graphitization of pearlite in irons with high Mn-S ratio.

ACKNOWLEDGMENT

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FACTORS AFFECTING METAL-MOLD REACTIONS

by G. A. Colligan, L. H. Van Vlack and R. A. Flinn

ABSTRACT

Previous work has determined the phase equilibria pertinent to iron and some iron-manganese alloys with silica. These investigations evaluated the equilibria at fixed temperatures and atmospheres (CO_2/CO gas mixtures).

The actual atmospheres obtained in a sand mold during casting operations are of great concern. In order to correlate the equilibrium data with actual practice, the effect of manganese additions and atmosphere on interface reaction was qualitatively evaluated. Identical step castings were produced in green sand and shell sand molds from iron base alloys containing 0.23 to 8.60 per cent manganese. The surface sintered layers were removed from all castings and microscopically examined.

The effect of an oxidizing mold atmosphere was demonstrated in the green sand castings by extensive reaction at the interface. The atmosphere produced by phenolic resin bonded shell molds resulted in slight reaction and reaction products typical of a less oxidizing atmosphere than green sand molds.

Manganese additions caused extensive silicate melt formation. The reaction became more pronounced with increasing manganese content in green sand molds.

A practical means of minimizing metal-mold reactions may be possible through the use of organic sand binders and additives which can control the interface atmosphere.

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(This paper is based upon a thesis submitted by G. A. Colligan to the Horace H. Rackham School of Graduate Studies of the University of Michigan in partial fulfillment of the requirements for the degree of Ph.D. in Met. Engrg.)

INTRODUCTION

Reactions at the mold-metal interface have produced serious problems in the field of cast metals. The reaction, which is the cause of fused sand, surface roughness and penetration, has been studied qualitatively by many investigators.[1-11] The preliminary work of the present authors[12] was the first attempt to study the pertinent phase equilibria in the iron-silica system where temperature and atmosphere were carefully controlled.

This preliminary work led to a comprehensive phase equilibria investigation which included the effect on interface reaction of manganese additions to the iron-base alloy. These results have been reported and are being published at the present time[13] Equilibrium diagrams summarizing these investigations are presented in Figs. 1 and 2.

Figure 1 shows that extremely reducing conditions are necessary to prevent a silicate melt (interface reaction). Furthermore, even small additions of manganese (Fig. 2) to the iron-base alloy make it difficult to avoid mold-metal reaction during solidification and cooling.

In view of these new equilibrium data, it seemed advisable to determine whether these effects were

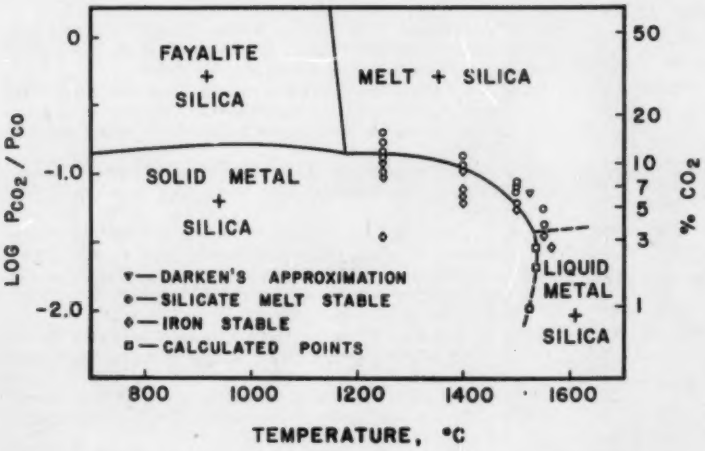

Fig. 1 — Fe-Si-O-C system from Darken[15] modified to include recent experimental results.[13] The system contains a strong excess of silica.

encountered under the nonequilibrium conditions experienced in commercial castings.

PROCEDURE

The actual atmospheres obtained in a sand mold during casting operations are of great concern. In order to correlate the equilibrium data[13] with actual practice, the effect of manganese additions and atmosphere on interface reaction was qualitatively evaluated on test castings in the following manner. Identical step castings were produced in green sand molds, shell molds (Fig. 3) and molds containing a shell sand drag and green sand cope. The sand mixtures are summarized in Table 1. By using a green sand mixture, an oxidizing condition is produced at the mold-metal interface.[11] The resin bonded shell mold produces strongly reducing conditions as determined by Van Vlack, Wells and Pierce.[14]

TABLE 1 — SAND MIXTURES FOR TEST CASTINGS

Description	Constituent	Weight, %
Green Sand	N. J. Silica Sand 140 mesh	92
	Western Bentonite	3.5
	Mogul Cereal	1
	Water	3.5
Shell Sand	N. J. Silica Sand 140 mesh	95
	Phenolic Resin	5

Melting Procedure

Cold-rolled A.I.S.I. 1018 bar stock was melted in a high frequency induction furnace. After melt-down, a small silicon addition was made to deoxidize the melt and allow recarbonization to the desired level. This level was calculated from experimental equilibrium data at 1550 C* (2822 F) under controlled atmosphere. The chemical compositions of these castings and pouring temperatures are recorded in Table 2, which contains a complete summary of experimental data. Low pouring temperatures were used initially to duplicate equilibrium data.

The manganese additions were made to the metal remaining in the furnace after the simple iron-carbon alloy was poured.

Casting Procedure

Iron base compositions with 0.23, 0.75 and 4.40 per cent manganese were each initially cast in a green sand mold and a shell mold to determine the effect of atmosphere and manganese content on interface reaction.

In order to eliminate the problem of pouring temperature variation, duplex molds were poured with 0.50 and 8.60 per cent manganese. These molds each contained a shell sand drag and a green sand cope. In this way a measure of the effect of atmosphere at the interface on reaction could be determined in one mold. All castings were poured from

*See Appendix

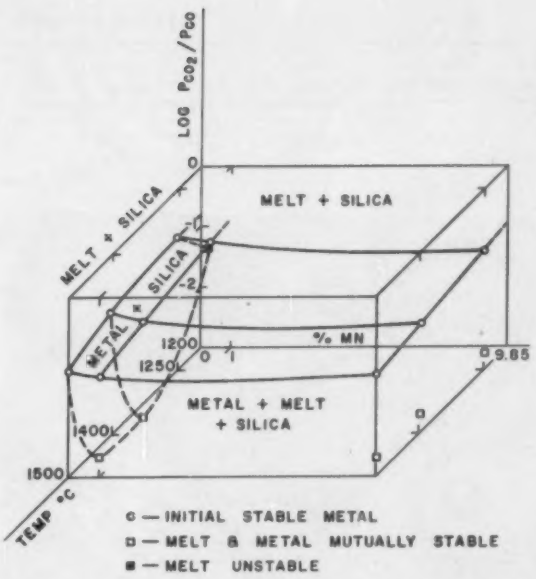

Fig. 2 — Fe-Si-O-C-Mn system in the presence of excess silica.

small ladles after the metal was tapped from the furnace.

Interface Reaction Evaluation

All castings were observed after cooling, and in some cases were photographed to provide a permanent record. The surface sintered layer was carefully removed from the castings for microscopic examination. Samples of appropriate sintered layer specimens were vacuum impregnated with thermosetting resin, mounted in thermoplastic resin and polished for high magnification observation.

RESULTS

The results of this qualitative investigation may best be considered under the following categories— (a) macroscale evaluation and (b) microscopic evaluation of interface reaction.

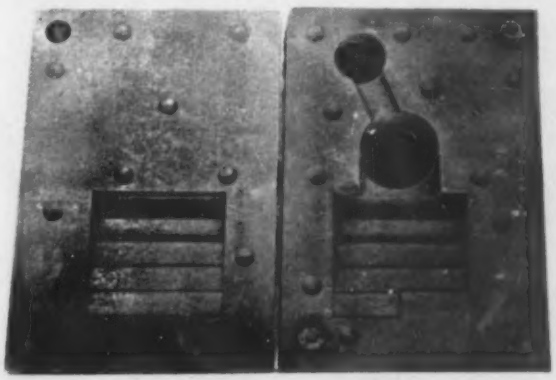

Fig. 3 — Shell mold for test step casting. Silica sand bonded with 5 per cent phenolic resin.

TABLE 2 — TEST CASTINGS SUMMARY

Heat No.	Casting No.	Mold Type	Pouring Temp., F	Surface Condition	Chemical Analysis (wt.,%) C	Mn	Si	P	S
1	E-1	Green Sand	2810	poor surface, extensive reaction	0.16	0.19	0.13	0.011	0.020
	E-2	Shell Mold	2760	smooth surface slight reaction	0.20	0.23	0.21	0.014	0.036
2	E-3	Green Sand	2810	poor surface, extensive reaction, low fluidity	0.18	4.10	0.33	0.011	0.019
	E-4	Shell Mold	2730	smooth surface, slight reaction, good fluidity	0.20	4.40	0.45	0.010	0.018
3	E-5	Green Sand	2950	extensive reaction, penetration, fusion	0.10	0.75	0.13	0.011	0.021
	E-6	Shell Mold	2940	slight reaction, fusion, no penetration	0.12	1.03	0.26	0.013	0.021
4	E-7	Shell Mold Drag Green Sand Cope	2950	slight reaction on drag, extensive reaction on cope	0.16	0.50	0.34	0.012	0.021
5	E-8	Shell Mold Drag Green Sand Cope	2800	slight reaction on drag, extensive reaction on cope	0.15	8.60	0.41	0.010	0.019

Fig. 4 — Test step casting E-1, 0.19 per cent manganese-iron alloy cast in green sand mold.

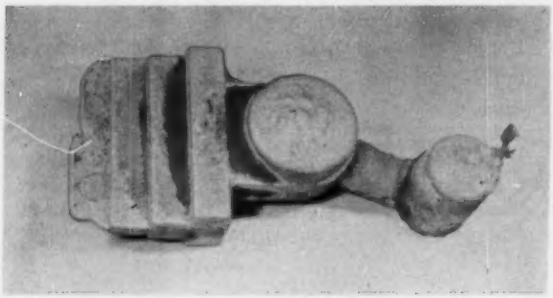

Fig. 5 — Test step casting E-2, 0.23 per cent manganese-iron alloy cast in shell sand mold.

Fig. 6 — Test step casting E-3, 4.10 per cent manganese-iron alloy cast in green sand mold.

Macroscale Evaluation

The first six step castings, each set of two containing a different nominal addition of manganese, were poured into green sand molds and shell molds. The details of the analysis, mold materials and pouring temperatures are recorded in Table 2. It should be noted that metal of a given nominal composition, as poured in the green sand mold, consistently yields lower manganese content in the final castings.

In general, the difference between green sand and shell sand was obvious at all levels of manganese. The oxidizing nature of the green sand mold produced extreme interface reaction, which resulted in poor surface finish, some metal penetration and extensive fusion of the silica at the interface. The reducing nature of the shell sand mold permitted little interface reaction. The surfaces were smooth, free of metal penetration and exhibited slight fluxing of silica.

Figure 4 shows the 0.19 per cent manganese alloy poured in a green sand mold. The heavy sintered layer and poor surface finish is obvious. Figure 5 is the same alloy poured in a shell mold. There is slight interface reaction and almost no sintered layer, i.e., fused zone of reaction products. The surface finish is smooth and the detail is far superior to the green sand casting in spite of the lower pouring temperature shown in Table 2.

Figure 6 shows the 4.10 per cent manganese alloy poured in a green sand mold. The extensive interface reaction has produced a heavy sintered layer and extensive silica fusion. Figure 7 illustrates the appearance of the 4.40 per cent manganese alloy poured in a shell mold. The casting exhibits good surface finish, some light reaction and silica fusion. The shell mold casting poured at the lower temperature has good detail and fluidity.

A second set of two castings was produced to eliminate the problem of pouring temperature variation. These molds consisted of a shell sand drag and a green sand cope. The first casting contained 0.50

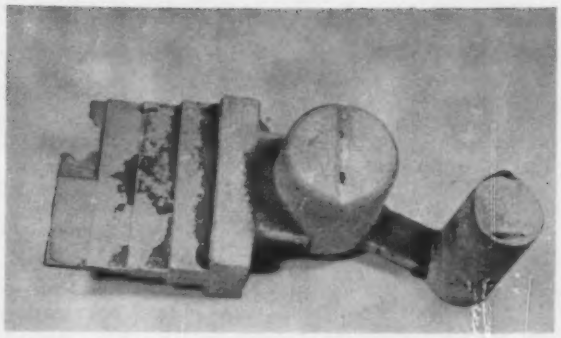

Fig. 7 — Test step casting E-4, 4.40 per cent manganese-iron alloy cast in shell sand mold.

per cent manganese, and exhibited a heavy sintered layer at the green sand interface and light reaction at the shell sand interface. The second casting was an 8.60 per cent manganese alloy. The green sand interface of this casting was rough and contained a heavy sintered layer. The shell sand interface was smooth with slight reaction and had no heavy adhering sintered layer.

Microscopic Evaluation of Interface Reaction

Microscopic examination of the sintered layer removed from the experimental castings yielded interesting results. Figure 8 contains the reaction products from the sintered layer of the 0.19 per cent manganese alloy cast in a green sand mold. There is extensive evidence of the formation of a liquid silicate melt at high temperature. This melt has essentially crystallized to fayalite on cooling. In addition to the quartz and cristobalite, the specimen contains a great deal of magnetite (the small skeletal crystals visible in Fig. 8).

Figure 9 shows the sintered layer from the 0.23 per cent manganese alloy cast in a shell mold. There is a small amount of silicate melt from the reaction at elevated temperature which has subsequently solidified as fayalite.

Figure 10 illustrates the typical structure of the reaction interface from the 4.10 per cent manganese

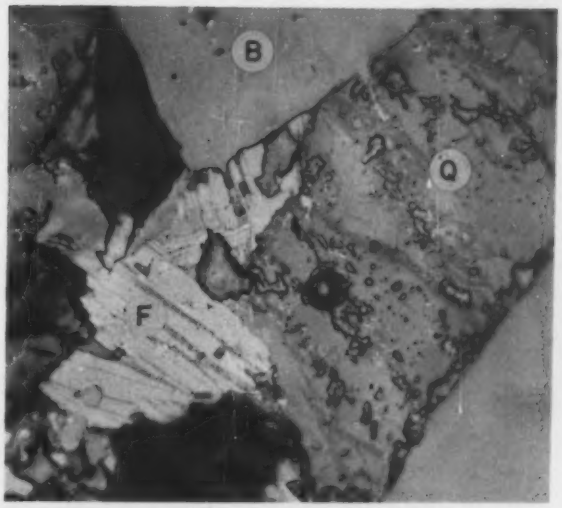

Fig. 9 — Microstructure of sintered layer from test step casting E-2, containing Fayalite (F), Quartz (Q) and Bakelite (B). Iron-0.23 per cent manganese alloy cast in shell sand mold. 500 ×.

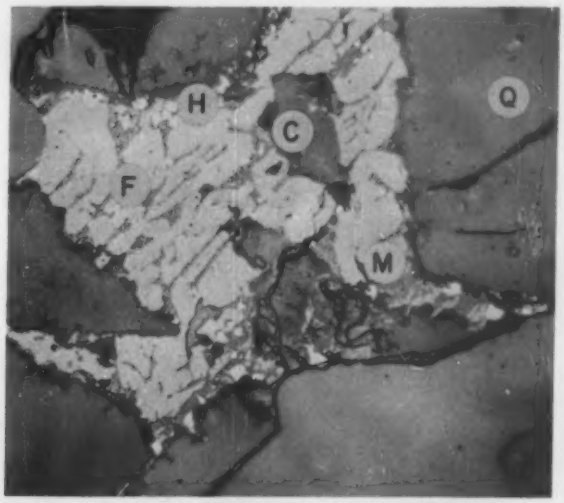

Fig. 10 — Microstructure of sintered layer from test step casting E-3, containing Hematite (H), Magnetite (M), Fayalite (F), Cristobalite (C) and Quartz (Q). Iron-4.10 per cent manganese alloy cast in green sand mold. 500 ×.

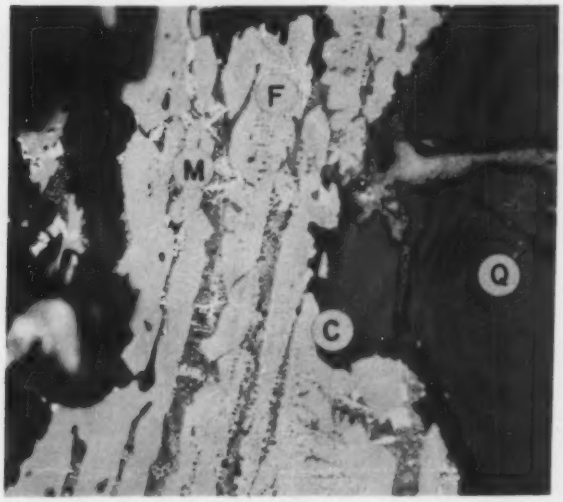

Fig. 8 — Microstructure of sintered layer from test step casting E-1, containing Magnetite (M), Fayalite (F), Cristobalite (C) and Quartz (Q). Iron-0.19 per cent manganese alloy cast in green sand mold. 500 ×.

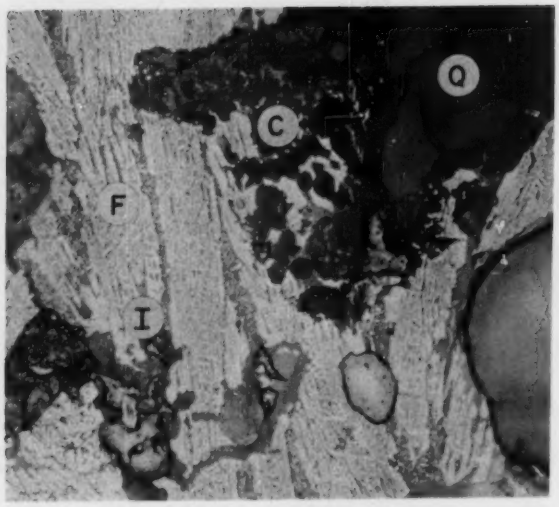

Fig. 11 — Microstructure of sintered layer from test step casting E-4, containing Iron (I), Fayalite (F), Cristobalite (C) and Quartz (Q). Iron-4.40 per cent manganese alloy cast in shell sand mold. 500 ×.

alloy cast in a green sand mold. There is extensive fayalite from the liquid silicate melt as well as magnetite and hematite. Figure 11 shows an alloy of the same nominal composition, 4.40 per cent manganese, poured into a shell mold. The sintered layer contains some fayalite from the liquid silicate melt and some spherical metallic crystals in the zone of the prior silicate melt.

The structure in the 0.75 per cent manganese alloys is the same. The green sand sintered layer reveals extensive reaction. The shell sand sintered layer indicates slight reaction with considerable reduction of iron from the silicate melt.

The duplex molds containing shell sand drag and green sand cope substantiate the results of the first series of castings. Figure 12 shows the sintered layer from the green sand cope of the 8.60 per cent manganese alloy. The extensive reaction zone contains fayalite and magnetite. The shell mold drag section of the same casting exhibits a sintered layer of the type illustrated by Fig. 13. The small amount of fayalite in this section is evidence that the reaction was slight, but there was extensive iron reduction when the liquid silicate melt was cooled.

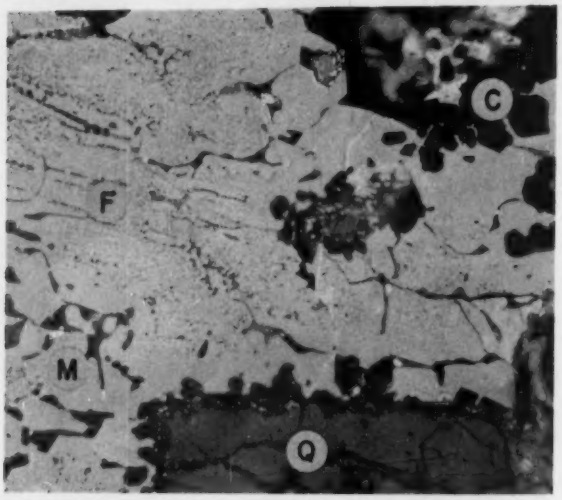

Fig. 12 — Microstructure of sintered layer from green sand cope of test step casting E-8, containing Magnetite (M), Fayalite (F), Cristobalite (C) and Quartz (Q). Iron-8.60 per cent manganese alloy cast in duplex mold. 500 ×.

ENGINEERING SIGNIFICANCE

The engineering significance of this investigation will be discussed in the following order—(a) penetration and interface reaction, (b) problem of manganese additions and (c) effect of mold material.

Penetration and Interface Reaction

There are two possible causes of metal penetration in a silica mold. Simple mechanical penetration occurs when the pressure exceeds the interfacial energy of the mold wall and causes the liquid metal to fill the interstices of the mold. In addition, chemical reaction at the interface may cause the mold wall to break down and allow metal penetration at low pressures.

There is extensive reference by earlier investigators of the formation of a low melting point slag at the

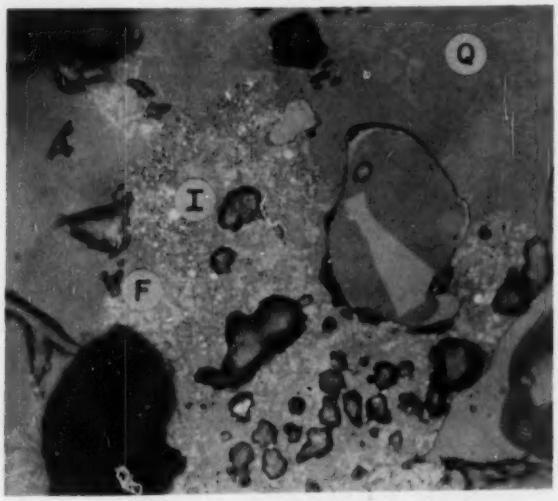

Fig. 13 — Microstructure of sintered layer from shell sand drag of test step casting E-8, containing Iron (I), Fayalite (F) and Quartz (Q). Iron-8.60 per cent manganese alloy cast in duplex mold. 500 ×.

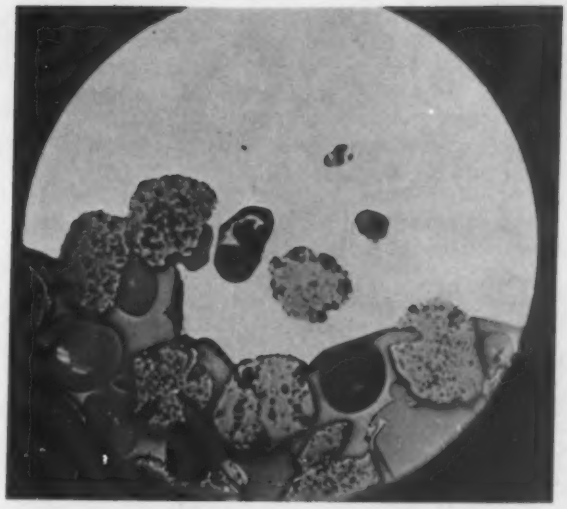

Fig. 14 — Microstructure of iron-silica interface after one hr at 1550 C (2822 F) in an oxidizing atmosphere of 3.9 per cent CO_2 — 96.1 per cent CO. The penetration of the iron is typified by the isolated quartz grains surrounded by iron. 25 ×.

mold-metal interface, but there is considerable confusion between the penetration of metal and the penetration of the low melting point slag. The same confusion has existed with respect to the terms "reducing" and "oxidizing" atmosphere, and the effect of these atmospheres on reaction and penetration.

The results of this investigation combined with the phase equilibria studies of the present authors[13] clarify the role of atmosphere in reaction and penetration. With pure iron-carbon alloys, the equilibrium diagram (Fig. 1) presents the range of atmosphere control necessary to prevent interface reaction, i.e., the formation of a liquid silicate melt. Observation of the phases present in the sintered layers of the green sand and shell sand molds indicates that normal cast metal practice operations lie above the boundaries between the liquid silicate melt field and the solid and liquid iron fields. The result is that extensive liquid silicate melt formation is experienced, with resultant loss of surface smoothness and detail.

The possibility of preventing interface reaction by the introduction of neutral or reducing gases in a mold is, therefore, slight and most impractical. Even vacuum treatment is not necessarily a potential solution. The atmospheres experienced in normal practice should more properly be classified on a relative oxidizing power basis, since their behavior is such a strong function of temperature.

Metal Penetration Problem

The problem of metal penetration is quite severe in heavy castings, but it can also be a serious problem in small castings. Prior investigators have indicated that under oxidizing conditions the metal might wet the silica grains and facilitate penetration. Previous work[11,13] proved that the formation of a liquid silicate melt, in itself, does not cause a great decrease in the interfacial energy between the liquid metal and solid silica. This confirmed Atterton's analogous results.[7]

However, the liquid silicate melt does attack the mold wall and greatly enlarge the pore size of the silica compact. This will then lead to metal penetration at low pressures. Figure 14, from the phase equilibria studies, clearly shows this mechanism in operation. This sample of an iron-silica couple was treated at 1550 C (2822 F) under oxidizing conditions, 3.9 per cent CO_2. The sample size removes pressure as an important variable. The results of the mold wall attack have allowed metal penetration to completely surround many silica grains. Under reducing conditions, a sample of the same size exhibited no reaction or penetration at 1550 C (2822 F).

Manganese Additions Problem

The data involving manganese content of the metal are quite significant. For many years it has been appreciated that manganese greatly aggravates the problem of producing castings with satisfactory surface finish. Experimental results[11,13] explain the reason for this difficulty. The effect of manganese on the stability of a silicate melt is graphically illustrated by the equilibrium data (Fig. 2). Even small additions, e.g., one per cent manganese, greatly lowered the reducing tendency of a given gas mixture.

It is essentially impossible, therefore, under the conditions investigated to prevent the formation of a liquid silicate melt in the presence of manganese. The higher the level of manganese addition to the iron-base alloy, the more severe was the interface reaction. This is verified in practice by the extremely severe mold wall attack of cast Hadfield steels which contain 13 per cent manganese. In view of these results, extensive use of manganese to improve hardenability in cast iron-carbon alloys should be avoided if good surface finish is a prime requirement.

Mold Material Effect

The effects of mold material and the resultant atmosphere are also demonstrated by the data. Practically speaking, it is impossible to attempt to control the mold atmosphere by introducing inert or reducing gas mixtures into a mold cavity. The comparative results of green sand and shell molds, however, hold some promise. In all cases the use of a sand mixture bonded by a polymerized phenolic resin yielded good cast surfaces, little reaction and improved fluidity. This was true at all levels of manganese additions, 0.23-8.60 per cent.

Increasing manganese content had a less severe effect on the interface reaction in the resin bonded

shell molds than in the green sand molds. Actually, the severity of the reaction in the green sand mold was more pronounced at 0.19 per cent manganese than the reaction in the shell mold containing the 8.60 per cent manganese-iron alloy.

The effect of manganese content on interface reaction in a given type of mold is evident from these experimental castings. In both green sand and shell molded castings, the degree of liquid silicate melt formation increased with increasing manganese content.

Microscopic investigation of the sintered layers from these castings provided valuable information. The sintered layers which were removed from the green sand interface of all the test castings contained extensive fayalite formed from the liquid silicate melt. In addition, these reaction zones contained magnetite and some hematite. To produce these higher oxides of iron upon cooling, the atmosphere must be considerably more oxidizing than the range of mixtures used in the equilibration investigations cited in Figs. 1 and 2.

In contrast to this behavior, the reaction zones which were removed from the shell molded castings contained products identical to the equilibration samples previously reported.[11,13] The presence of fayalite confirmed the existence of a liquid silicate melt, but the extensive amount of iron reduced from the silicate melt on cooling indicates the relatively reducing nature of the atmosphere.

Since the same results were produced in a duplex mold with a green sand cope and shell sand drag, control of mold atmosphere at the interface may be possible. Organic sand binders similar to the phenolic resin used in this investigation may be a means of minimizing the undesirable interface reaction.

CONCLUSIONS

The results of an extensive phase equilibria investigation[13] were evaluated and verified by the pouring of selected step castings. The effect of an oxidizing mold atmosphere was markedly demonstrated in castings produced in green sand molds. The surface finish and interface reaction zone exhibited the pronounced influence of manganese by extensive liquid silicate melt formation over the entire range of manganese additions. The atmosphere produced by phenolic resin bonded shell molds, which oxidizes to a lesser degree than that of the green sand molds, resulted in slight interface reaction over the range of manganese content of 0.23-8.60 per cent. In all cases, the minor attack and the resultant reaction products indicate that the atmosphere was extremely reducing relative to green sand molds.

These results indicate that a practical means of minimizing interface reactions may be possible through the use of organic sand binders which can control the interface atmosphere. In addition, the need for equilibria studies in other refractory oxide systems, and for the evaluation of the effects of other alloy additions to the iron-base melt, is apparent. Thus, by a better understanding of these equilibria combined with a knowledge of the kinetic aspects of reactions during casting, the problem of interface reactions may be controlled.

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APPENDIX

The calculated carbon composition for these castings was based on the equilibrium diagram of Fig. 1. Since experimental results were available for a temperature of 1550 C (2822 F), this temperature was used to determine the atmosphere which would fix the carbon composition of the iron-carbon alloy. At 1550 C (2822 F), the boundary between liquid iron, silica and liquid silicate melt, silica is fixed at 3.9 per cent CO_2 – 96.1 per cent Co. By using available thermodynamic data, the carbon composition in equilibrium with this gas mixture may be calculated as follows:

$$CO_2 + \underline{C} \rightarrow 2\,CO$$

$$K = \frac{[P_{CO}]^2}{[P_{CO_2}]\ [\text{wt. \% C}]}$$

$$\log K = \frac{-\Delta H^\circ}{4.575\ T} + \frac{\Delta S^\circ}{4.575}$$

$$\text{at } 1550\,C \quad \log K = \frac{-32{,}350}{(4.575)\ (1823)} + \frac{27.70}{4.575}$$

$$\therefore K = 149.9 = \frac{[0.96]^2}{[0.039]\ [\text{wt. \% C}]}$$

$$\therefore \text{wt. \% C} = 0.157$$

The nominal carbon composition used in the charges for the experimental heats was this value of 0.157 per cent C.

STEEL FOUNDRY SAND CLAY BONDING

A microscopic study

by J. B. Caine, E. H. King and J. S. Schumacher

ABSTRACT

Microscopic examination of steel foundry sands casts doubts on accepted theories on "clay film thickness" and "clay distribution" by mulling. Methods for microscopic examination are given.

INTRODUCTION

There are many references in the literature to "clay film thickness" and the effect of mulling on "clay distribution." A study of these references reveals that in most, a uniform distribution of the bond clay about the sand grain is assumed but not proved. In mulling studies clay distribution is assumed to be better when green strength increases. Green strength does increase with mulling up to a point, but this is no proof that distribution in itself has changed.

Foundry sand technology abounds with such basic, unproved assumptions that may, or may not be, correct. In an effort to check the two previously mentioned basic assumptions a microscopic study was made. It should be emphasized that the findings reported in this paper merely present the problem. The reader should be warned not to jump to further conclusions that have not been proved. The problem is too important and too basic to compound present confusion by more assumptions not based on fact.

This particular investigation must be restricted to steel foundry sands, for such sands constitute the great majority of the sands studied. However, there seems no reason why the basic findings cannot be extended to all foundry sands, although there will be some differences in detail. The microscopic examination of sand requires different techniques than for metal. A detailed explanation is in order for the proper interpretation of the photomicrographs in this paper.

INDIVIDUAL SAND GRAINS

Sand grains and their coatings can be studied by oblique illumination, as in Fig. 1. Such illumination is ideal for uncoated grains, but does not show much as to the coating – especially its thickness and distribution. Angular transmitted illumination, as in Fig. 2, gives a shadow picture of the relative amount, thickness and distribution of the bond coating.

Normal transmitted illumination, as is standard with the biological microscope, does not seem as good

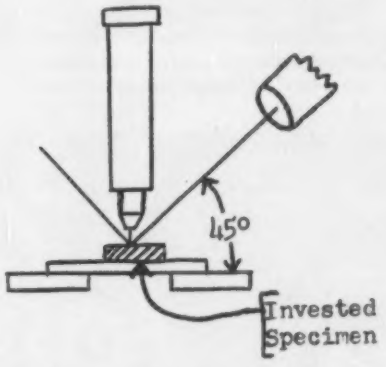


Fig. 1 — Equipment setup for examining sand specimens under oblique illumination.

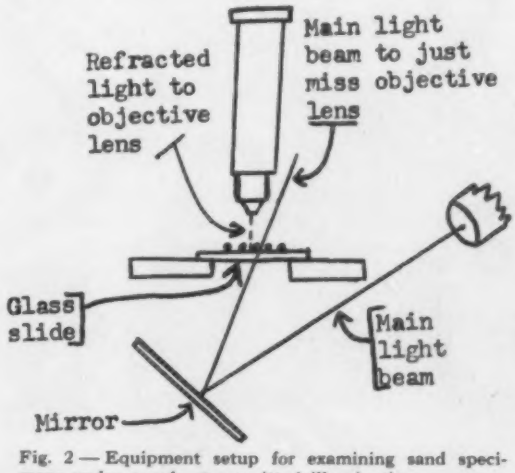


Fig. 2 — Equipment setup for examining sand specimens under angular transmitted illumination.

J. B. CAINE is Consultant, E. H. KING is Pres. and J. S. SCHUMACHER is Vice-Pres., The Hill and Griffith Co., Cincinnati, Ohio.

as the angular transmitted illumination of Fig. 2. The main light beam in normal transmitted illumination is focused directly into the objective lens and is unimpeded through the spaces between the loose sand grains blinding the viewer, or causing excessive photographic contrast. A study of loose, individual sand grains is restricted to magnifications less than 30 diameters (30 ×) due to too short a depth of focus at higher magnifications.

RAMMED SAND COMPACTS

The study of rammed sand compacts requires different preparations than individual sand grains. First, the distribution of the compact must be preserved. This can be done by carefully investing the compact in a thermosetting plastic. Phenol resin core binder rendered opaque with a little lamp black is handy for the foundry, for the materials are available in most core rooms and pattern shops. The resin is set at as low a temperature as possible to prevent bubbles. This usually requires 24 hr at under 200 F. The specimen is then polished just like a metal specimen. Vertical illumination shows little, so oblique illumination is used. Such illumination restricts magnification to about 250 × with a 4 mm objective. Sufficient light is difficult to transmit to objectives of shorter focal length.

The technique used in other fields of examining thin sections by transmitted light has not been used due to lack of equipment for specimen preparation. It is not known if such specimens will tell more than those used in this study.

MICROSCOPIC STUDY

Figure 3 shows a series of sand photomicrographs used to "zero in" on the study of individual sand grains. Figure 3a shows the sand unbonded, and is typical of many shown in the past. Figure 3b shows the same sand bonded with 6 per cent western bentonite to which a pinch of lampblack was added for photographic contrast under oblique illumination. At first glance the grains seem uniformly coated, but on close examination irregularities can be seen.

Transmitted light, as in Fig. 3c, shows a different picture. The light areas on the sand grains have either no coating or a thin coating of bentonite. Most of the bentonite is concentrated in spots or rings. If Fig. 3c is believed, it is necessary to revise our thinking about clay coatings on sand grains. There is no such thing as "clay film thickness." Instead a nonuniform coating seems to be a basic premise. It must be emphasized that Fig. 3c is not a freak; it is representative of several hundred specimens.

Figure 3d shows the same sand after dry reclamation to 3 per cent AFS clay. The decrease in the amount of coating is apparent. Figure 3e shows the same sand after the standard washing to remove clay. Only the clay that is in the pits remains.

It should be emphasized that the light and dark areas of Fig. 3c and those to follow do not designate areas of clay and no clay. Figure 3b shows that there is a coating over the whole grain. The light and dark areas shown by angular transmitted light only designate areas of varying clay film thickness.

Photomicrographs of this paper, especially Fig. 13, indicate that the dark areas have a clay film thicknesses of about 0.0005 in. The clay film on the light areas cannot be seen on a cross-section at 250 ×, and is probably in the order of 0.00005 in. thick or less. A basic question that cannot be answered at this time is how thick must the clay film be in order to bond two spherical particles.

MULLING EFFECT

Figures 4 and 5 show sands after two mulling cycles in two types of mullers. Microscopic studies to date show little difference in clay distribution during the usual mulling cycles of the steel foundry. Either slight differences in distribution of the coating on the sand grains are significant, or other explanations are necessary for the changes in properties due to mulling. Mulling is usually evaluated by green strength. It has been the assumption that green strength is related to bond dispersion, and that increased dispersion of the bond results in increased green strength. Figures 4 and 5 cast doubt on this basic assumption.

There is at least one other possible explanation for the variation in mechanical properties of the sand due to mulling. This is – changes in the bond itself. Mulling "plasticizes" all clays by developing strength, adhesion and cohesion. It is just as probable that this plasticizing of the clay is responsible for the increase in green strength, deformation and dry strength, as that these properties are due to an unobservable increase in dispersion of the clay.

DISCUSSION

If the discussion is restricted for the moment to typical low clay content steel sands, considering only green strength and deformation, mulling to maximum values may be detrimental. Flowability or moldability of any clay bonded sand decreases with increased green strength due to mulling. Only a minimum green strength is required for mechanical strength during molding. Any excess green strength, as distinguished from green strength as a measure of clay content for thermal stability, is a disadvantage.

The same can be said for deformation. Only a minimum deformation is required to prevent cracking and sticking during molding due to misalignment. Unless deformation is a measure of some phase of thermal stability, any excess is a disadvantage in decreasing flowability.

Dry strength is another property that is increased by mulling. Dry strength may be related to certain phases of thermal stability, which is the important property of a molding or core sand. If this is true there are ways to increase dry strength other than mulling, and retain moldability. One method is a slight increase in water content, combined with a shorter mulling cycle.

However, slight variations in water content in themselves do not seem to change clay distribution greatly. A number of sands were mulled in the laboratory with water contents from 2 to 25 per cent with 6 per cent bentonite. There was no increase in dispersion over that of Figs. 3 to 5 as the water was increased from 2 to 15 per cent. A definite increase in dispersion was found with over 20 per cent water, but these sands

were not moldable. They were no longer molding sands, but approached slurries.

UNIFORM SAND COATING METHODS

Only two methods have been found to date to approach uniform coating of sand grains with clay: high clay content and reuse of the sand in the foundry. Figure 6 shows that 12 to 18 per cent western bentonite almost covers the sand grains. Figure 6c shows about the same amount of coating with Ohio fireclay. Reuse of sand is restricted in the steel foundry due to danger of scabbing, but the point is interesting. Figure 7 shows the sand from one steel foundry using a minimum of new sand. An appreciable number of grains are completely covered. Figure 8a shows a

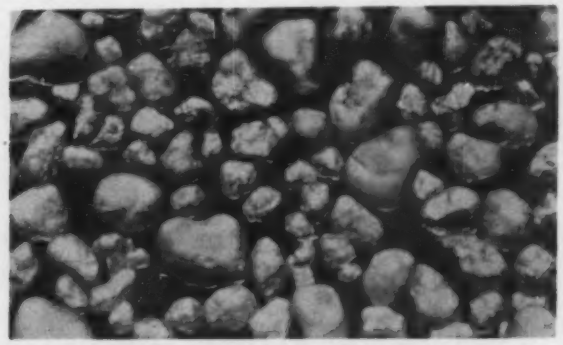


Fig. 3a — Washed and unbonded Ottawa type sand. Oblique illumination. 25 ×.

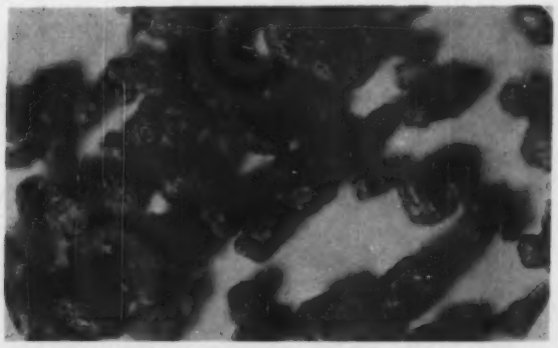


Fig. 3b — Same sand as in Fig. 3a, but bonded with 6 per cent western bentonite. Oblique illumination. 25 ×.

Fig. 3c — Same sand as in Fig. 3b, but using angular transmitted illumination. 25 ×.

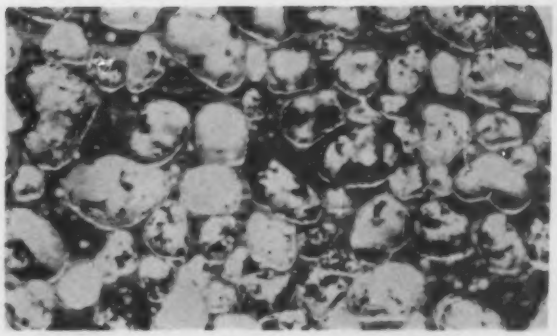


Fig. 3d — Same sand as in Figs. 3a and 3b, but after dry reclamation to 3 per cent AFS clay. Angular transmitted illumination. 25 ×.

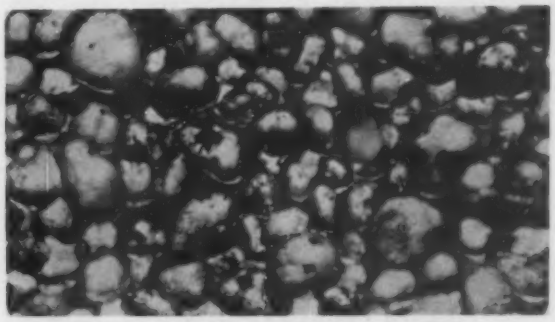


Fig. 3e — Same sand as in Figs. 3a, 3b and 3c, but after the clay has been removed by the AFS washing method. Angular transmitted illumination. 25 ×.

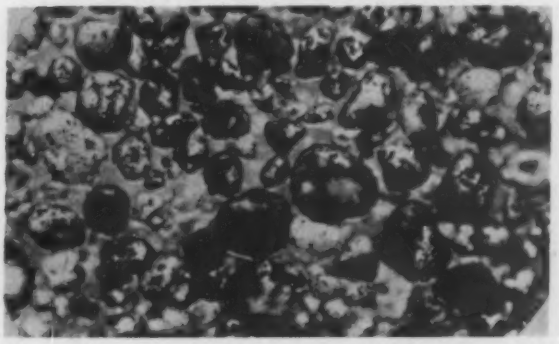


Fig. 4a — Sand with 6 per cent western bentonite added, mulled one min in a slow speed muller. Angular transmitted illumination. 25 ×.

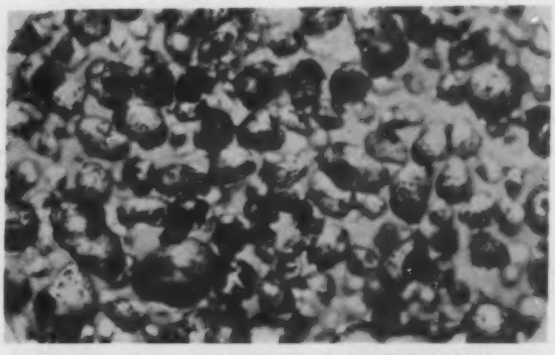


Fig. 4b — Same sand as in Fig. 4a, mulled 6 min in a slow speed muller. Angular transmitted illumination. 25 ×.

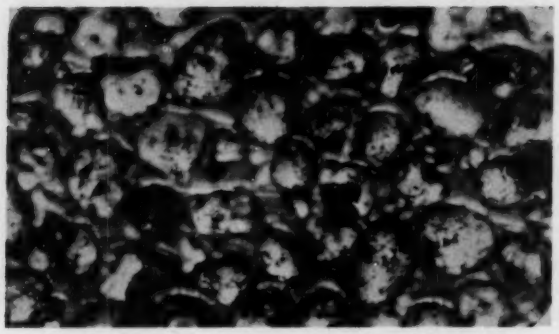


Fig. 5a — Sand with 6 per cent western bentonite added, mulled 20 sec in a high speed muller. Angular transmitted illumination. 25 ×.

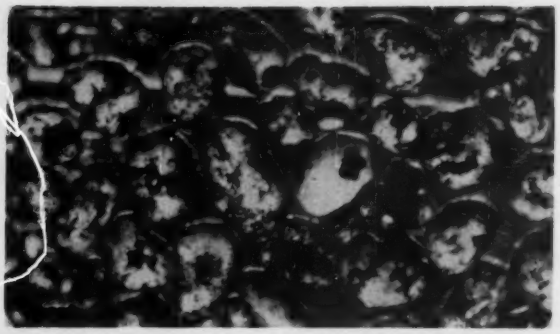


Fig. 5b — Same sand as in Fig. 5a, mulled 60 sec in a high speed muller. Angular transmitted illumination. 25 ×.

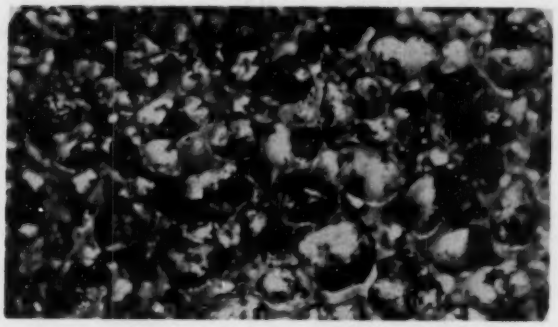


Fig. 6a — New sand with 12 per cent bentonite and 8 per cent water. Angular transmitted illumination. 25 ×.

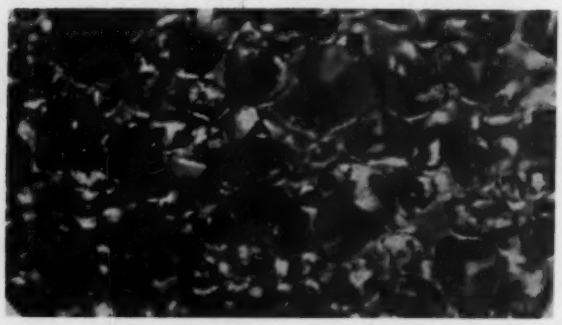


Fig. 6b — New sand, 18 per cent western bentonite, 6 per cent water. Angular transmitted illumination. 25 ×.

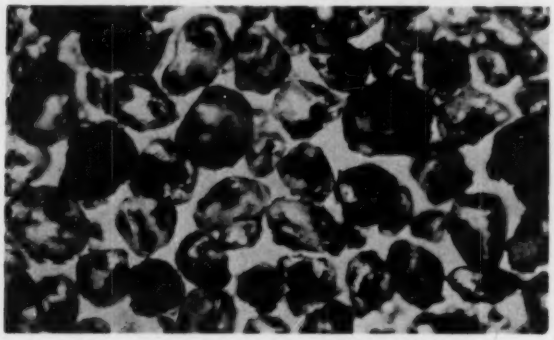


Fig. 6c — New sand, 18 per cent Ohio fireclay, 6 per cent water. Angular transmitted illumination. 25 ×.

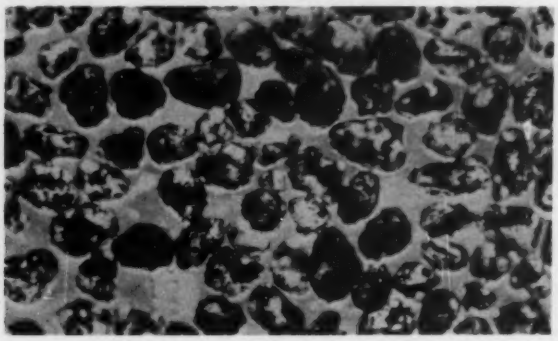


Fig. 7 — Steel system sand, 8 psi green strength, 10 per cent AFS clay. Angular transmitted illumination. 25 ×.

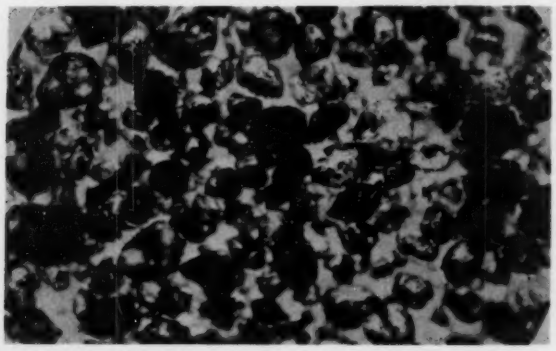


Fig. 8a — Iron system sand, 26 psi green strength, 17 per cent AFS clay, 5.1 per cent loss on ignition. Angular transmitted illumination. 25 ×.

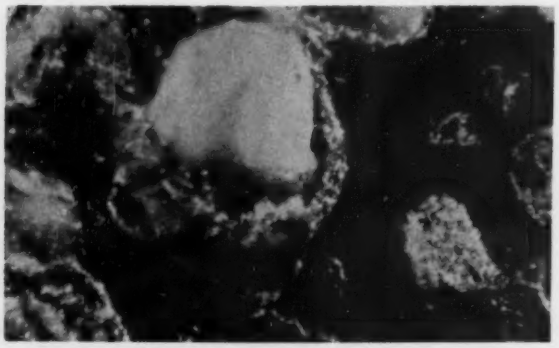


Fig. 8b — Same sand as in Fig. 8a, invested and polished. Oblique illumination. 125 ×.

Fig. 9 — New steel core sand containing 25 per cent silica flour, invested and polished. Oblique illumination. 125 ×.

system sand used in an iron foundry whose grains are almost completely covered.

The assumption should not be made at present that it is desirable to have uniformly covered sand grains in the steel foundry. Other factors must be taken into consideration. For example, the steel sand of Fig. 7 does not make particularly good castings, in fact the castings could be classed as under average. Figure 8b shows the iron sand of Fig. 8a after investing with plastic, polishing and examining at higher magnification. The loose shell around one sand grain is evident. This sand makes excellent iron castings, but such loosely bonded sand grains can be suspected as one reason steel sands fail on continued reuse without reclamation.

Figure 8b introduces the second microscopic technique for sands, that of the study of rammed sand compacts, invested with a mounting medium and at relatively high magnification. A fundamental point here is the identification of the phases. There is little doubt of the silica grain of Fig. 8b, and that this silica grain is surrounded by a relatively thick coating of another phase. It seems safe to assume that the surrounding phase is nongranular in the sense that the silica grain is granular.

The main nongranular materials present in this sand are western bentonite and sea coal from the additions. This bentonite and sea coal would be dehydrated and charred from heating during reuse. The "coky" appearance of the shell of Fig. 8b is typical of reused sands, which is different than the appearance of fine silica particles, as the silica flour particles of Fig. 9.

HIGH MAGNIFICATION TESTS

Figure 10 is shown as the basis of comparison for the evaluation of bond coatings at high magnification on unbonded, white silica sand. This specimen was vibrated in a test tube to 61 per cent density, invested, solidified and the test tube broken away from the specimen. Note the chains of white refraction dots around the sand grains. These dots, at present,

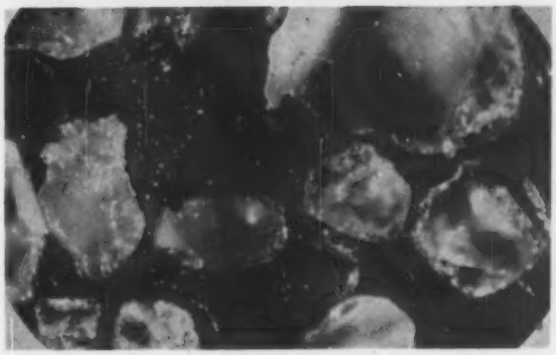


Fig. 10 — Washed, unbonded sand, invested and polished. Oblique illumination. 125 ×.

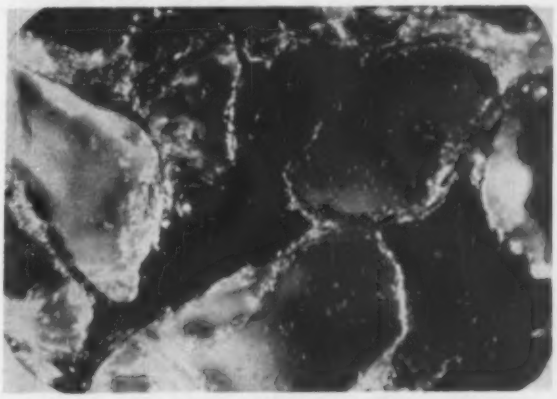


Fig. 11 — Surface coated with western bentonite slurry to distinguish bentonite, invested and polished. Oblique illumination. 125 ×.

Fig. 12 — Coating obtained with 18 per cent Ohio fireclay, invested and polished. Oblique illumination. 125 ×.

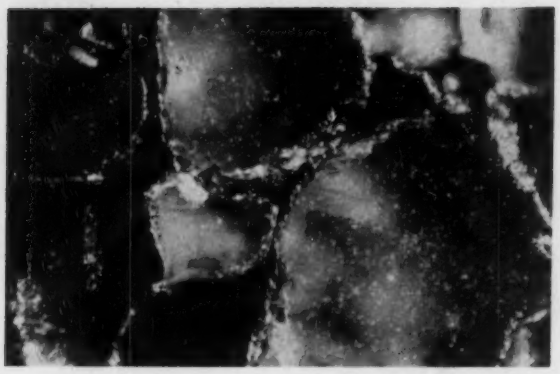


Fig. 13a — Production steel facing sand, 8 per cent bentonite. Clay areas 0.00056 in. thick. 125 ×.

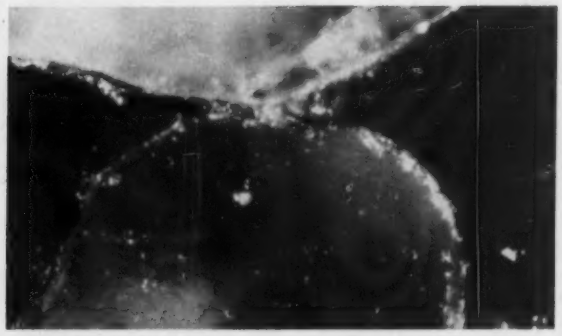


Fig. 13b — Production steel facing sand with 8 per cent bentonite. Clay areas 0.0005 in. thick. 250 ×.

interfere with the evaluation of small amounts of bond coatings. The white refraction dots of Fig. 10 must sometimes be used as sort of a blank in the evaluation of thin bond coatings.

Figure 11 is an attempt to establish the appearance of western bentonite at relatively high magnification. It shows a coating of western bentonite along the top, horizontal surface made by dipping a sand specimen in a bentonite slurry. The bentonite appears "pearly" under visual examination. A normal bonded contact between two sand grains is seen in the right center of Fig. 11. Figure 12 illustrates a relatively thick bond coating, formed in this instance by 18 per cent Ohio fireclay. The fireclay does not seem as translucent as western bentonite, but the difference is slight.

Figure 13 illustrates the appearance of what is now considered normal bentonite coatings, 6 to 8 per cent, at successively higher magnification. These are production steel facing sands. Note the bond at the grain contacts. Figure 13b shows bond at the grain contact, a gap and a spot of bentonite away from the contact. It should be emphasized that areas showing bond contacts are not easy to find under the microscope.

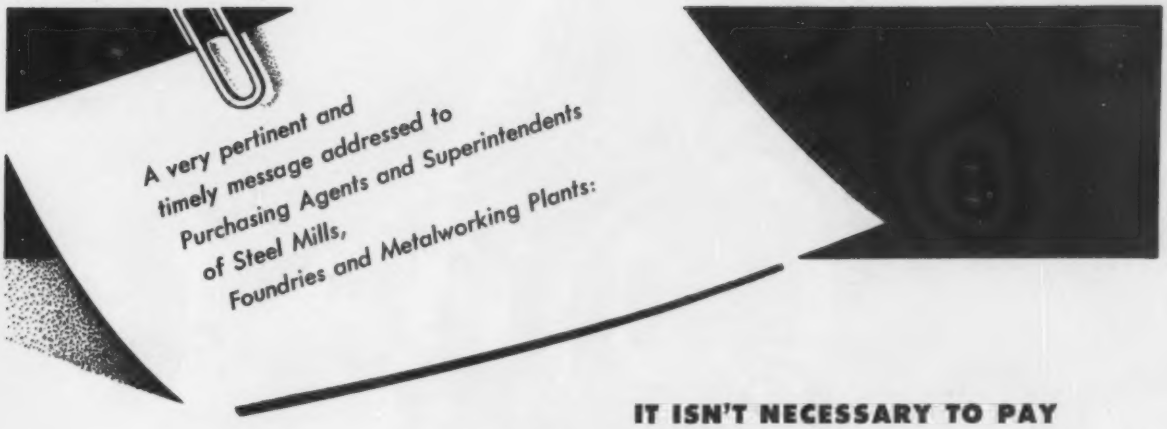
This may, or may not be as it should. First, the examination of a single plane through a three dimensional mass cannot be used, except statistically, as a criterion of the mass. Perhaps particles that do not seem bonded on a single plane are bonded on a different plane. Then, too, the nonuniform coating makes it improbable that every contact point will be bonded.

This last point indicates that a uniform coating may be an advantage. This is probable, except for one point – there is the possibility of two grains sliding against their unbonded surfaces during ramming until they hit a spot of bond. If this action could be relied upon it would enhance flowability and moldability without sacrifice of bonding. These points can be studied and evaluated quantitatively, if this is done statistically. However, the study quickly becomes complicated to the point of the order-disorder mechanics of atomic physics.

SUMMARY

It was stated in the introduction that the findings of this paper merely present the question or problem. The results to date can be summarized as follows:

1) The theories of uniform distribution of clay substance on sand grains and clay film thickness, within the ranges of clay content and water used in the steel foundry, are possibly in error. Perhaps all that can be hoped for with present bonding techniques is a varying degree of nonuniformity.
2) Mulling over short intervals of time does not increase clay distribution as evaluated by this paper. The increase in green and dry strengths with increased mulling may not be due primarily to improved distribution of the bond. The increase in green strength may be detrimental in that moldability is decreased. The role of dry strength in steel sands is not clearly understood.
3) Techniques of specimen preparation for microscopic examination are given. Preliminary qualitative methods for differentiation of the various bond constituents are given.



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Circle No. 126, Pages 141-142

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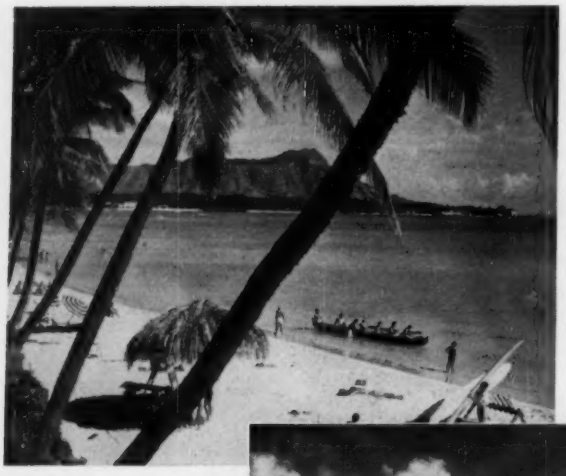

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16	Fly to City of Hilo, Sightseeing
17	Leisure and sail on Catamaran visit to Pearl Harbor
18	Famous Kodak Hawaiian Hula Show
19	Last Day, relax or shop
20	Arrive at San Francisco

TOUR "B"—$475.76

Basis: Two in twin-bedded room with bath at hotels. Single room supplement $43.75. For those returning by steamer on Tour "B" the cost will be $483.38 (minimum priced steamship accommodation).

ITINERARY TOUR "B"

May 13 thru 18	Same arrangements as Tour "A".
19	Fly to Garden Island of Kauai, for full day of sightseeing
20 & 21	Days of Leisure on Waikiki
22	Embark on the Lurline of the Matson line for San Francisco or Pan Am Airways
23	Air passengers arrive in San Francisco
23 thru 27	Passengers returning via the Lurline

(Reservations limited and will close on March 1, 1961).

TO: AMERICAN FOUNDRYMEN'S SOCIETY **Date**_____
Golf and Wolf Roads, Des Plaines, Illinois

Please reserve_____place(s) on ☐ Tour "A", ☐ Tour "B" of the AFS Post Congress Tour and Adjourned Session of the 65th Castings Congress & Exposition in Honolulu, Hawaii. ☐ Enclosed is a check made out to Thomas Cook & Son for $100.00 for each place reserved and we understand that this deposit will be applied to the full fare which is payable by April 1, 1961.

☐ We wish to go by JET Roundtrip ☐ We wish to go JET out and SHIP return (only available on Tour "B".)

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Castings Congress Paper Interest for 1961 Setting New High

A record number of technical papers submitted for consideration at the 65th Castings Congress indicates an outstanding program.

Quality of the technical program is assured by the various divisions. Each developes its own program with its Program and Papers Committee approving the papers. These committees are composed of the top authorities in the field.

Typical of the scope of the sessions is shown by the Sand Division. Nine papers have been approved to date, four committee reports are tentatively proposed, and two shop courses are scheduled.

Four of the papers deal with a systematic approach to various sand problems. Authors Arthur Zrimsek and George Vingas, Magnet Cove Barium Corp., Arlington Heights, Ill., presented the first paper in this series at the 1960 Convention. Reports 2, 3, 4 and 5 deal with interpretation of data, the effects of wood flour, dry properties of clay bonded sands, and mulling effects. Investigations in each paper are documented with graphs and charts.

Other papers approved include: "Granular Movement During Squeezing" by D. C. Williams, Ohio State University, Columbus, Ohio; "A Microscopic Study of the Bonding of Steel Foundry Sands by Clays," J. B. Caine, consultant, Cincinnati; "A Study of the Carbon Dioxide Process", Lt. G. D. Haley, WaiMet Alloy Co., Dearborn, Mich., and J. L. Leach, University of Illinois.

The tentative committee reports include status on the progress of the new handbook, work on veining investigations, a final report on the Bakeability Committee; and a report on inclusions.

Two shop courses will supplement the technical papers. One is planned on the new furfural type binders, the other with green sand molding methods.

Convention Includes Business Meeting

An important portion of the annual convention is devoted to the interests of the Society. These will be held on Wednesday, May 10.

Included will be the election of officers, honoring of national apprentice winners, the Charles Edgar Hoyt Memorial Lecture, Awards of Scientific Merit, and AFS Service Citations.

The annual banquet will be held Wednesday evening and AFS Gold Medals will be awarded.

Schedule Luncheons and Shop Courses

Technical sessions will be supplemented by luncheons and shop courses. Six shop courses will be held, two each by the Sand and Gray Iron Divisions, and one each by the Pattern and Ductile Iron Divisions.

Division luncheons will be held the first four days of the Convention. Refer to program below.

Tentative Schedule of Technical Sessions
65th AFS Castings Congress—May 8-12, 1961—San Francisco

Time	Monday	Tuesday	Wednesday	Thursday	Friday
9:30 to 11:30 am	Brass & Bronze Malleable Pattern	Brass & Bronze Pattern Malleable Light Metals T&RI Trustees	Annual Business Meeting & Hoyt Lecture	Steel Ductile Iron Fundamental Papers Die Casting & Perm. Mold	Sand Ductile Iron Fundamental Papers
12:00 noon Luncheons	Joint Gray, Ductile & Malleable	Brass, Bronze Pattern Board of Directors	Light Metals R. T.	Steel Die Casting R. T. Past Presidents	
2:00 to 4:00 pm	Pattern Brass & Bronze Heat Transfer	Light Metals Industrial Engrg. & Cost Gray Iron Sand	Steel Gray Iron Plant & Plant Equipment	Fundamental Papers Sand	
4:00 to 5:30 pm	Sand Brass & Bronze SH&AP Malleable	Education Light Metals Gray Iron Malleable	Industrial Engrg. & Cost Die Casting & Perm. Mold Sand Steel	Steel Gray Iron Die Casting & Perm. Mold Ductile Iron	
6:00 pm		Canadian Dinner	Annual Banquet	Alumni Dinner	
8:00 to 10:00 pm	Sand Shop Course Pattern Shop Course	Gray Iron Shop Course Sand Shop Course		Gray Iron Shop Course Ductile Iron Shop Course	

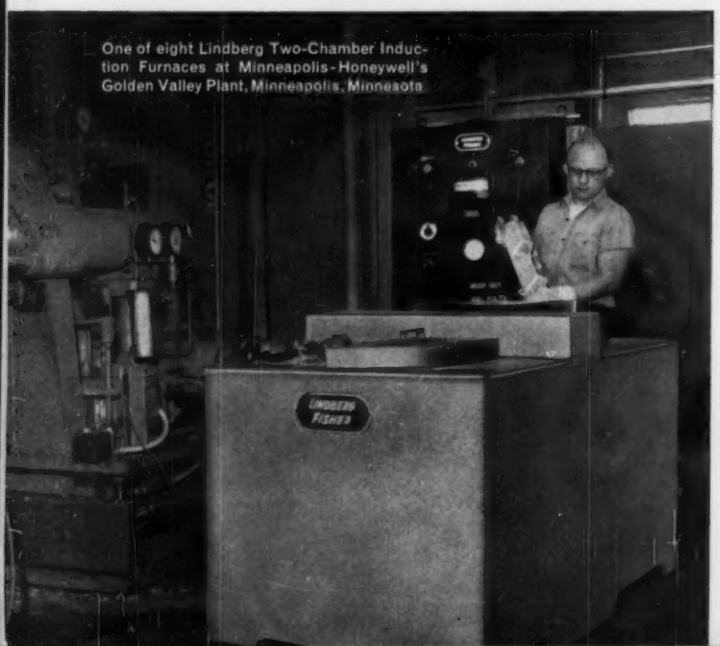
ART GEORGE has a good word to say for Lindberg Melting Furnace performance

QUOTE

Mr. Art George, Senior Production Engineer, Golden Valley Plant, Minneapolis-Honeywell Regulator Company, Minneapolis, Minn.

"Our installation of eight* Lindberg-Fisher Two-Chamber Induction Melting and Holding Furnaces has given remarkable service for more than four years. In this period, with the help of a well executed Honeywell maintenance program, the installation has been unusually trouble-free. Only one of the eight furnaces has required relining over this long period. Handling more than 1,000,000 pounds of aluminum and zinc annually, the installation has unfailingly provided the consistently high quality of metal our precision instruments require."

**Altogether, 44 Lindberg Furnaces are in operation in various Honeywell plants.*



One of eight Lindberg Two-Chamber Induction Furnaces at Minneapolis-Honeywell's Golden Valley Plant, Minneapolis, Minnesota

These eight Lindberg-Fisher Induction Furnaces melt and hold aluminum and zinc for die casting gas valve housings and other component parts. They are located at the die casting machines where ingot and scrap can be melted and held at the desired casting temperature in one convenient unit. Magnetic fluxing and stirring insures uniform temperatures and consistently clean metal.

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NEWS and VIEWS

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Nominate Officers, Directors
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T&RI Announces 1961 Courses for Upgrading Personnel

Up-grading key foundry personnel through the AFS Training & Research Institute begins its fifth year. Three new courses have been added to this highly successful program for improving plant personnel. These are: "Defects – Causes and Remedies;" "Cleaning Room Operations;" and "Production Scheduling and Control."

The program is designed to improve the industry's needs for practical, scientific, and technical operating personnel. AFS membership is not required for enrollment.

Fifteen courses will be held this year, starting in January and continuing through December. Four will be co-sponsored by AFS Chapters on a regional basis. Cities to be visited include five in the United States and Hamilton, Ontario, Can.

Industry's acceptance is shown by the more than 1500 registrants attending the 51 courses given to date in this country and Canada. Students have registered from 37 states, four provinces of Canada, South America, Asia and Europe.

During the past four years, more foundry foremen have attended the courses than any other group.

Other job titles in the top ten in order of attendance are superintendent, metallurgist, foundry engineer, sales engineer, maintenance foreman, assistant superintendent, technician, melting supervisor, and sand technician.

Students attending the courses represent the leading foundry areas. The ten states with the largest enrollments are Illinois, Wisconsin, Michigan, Ohio, Indiana, New York, Pennsylvania, Alabama, California, and Tennessee.

Gating and Risering of Castings Jan. 9-10 Houston, Texas $45

Instruction course covering theory and practice of ferrous and non-ferous alloys. Subjects include metal flow, solidification, heat transfer, shrinkage, hot tears, ferro-static pressure, gate and riser design, mold wall movement, and turbulence. Intended for foremen, patternmakers, foundry engineers, supervisors, industrial engineers, and production and quality control personnel. Specific problems are welcome. Course No. 7

Cupola Melting of Iron Jan. 30-Feb. 2 Chicago $90

Instructional course for cupola operators, supervisors, metallurgists, and foremen. Covered are basic principles for efficient cupola operation, including raw materials, charging procedures, cupola design, combustion control, metallurgy of cast iron, maintenance, new developments and equipment, water-cooled, hot and cold blast operations. Course No. 2

Sand Control and Technology Feb. 13-15 Chattanooga, Tenn. $60

Instruction course for foundrymen having had some experience in sand testing, control, and technology. Under treatment are mold wall movement, hot deformation, creep deformation, mold atmosphere, heat transfer, mechanical properties, and metal penetration. Students are encouraged to bring their problems for discussion. Course No. 3

Production of Ductile Iron Feb. 22-24 Chicago $60

Melting equipment and melting practices are emphasized for lower production costs. All phases of production are presented—metallurgy, inoculants, quality control, pouring practices, raw materials and inspection methods. A specialized course for personnel producing ductile iron or contemplating entering this field.

Preventive Maintenance		$45
Course No. 5	March 2-3	Hamilton, Ont.
Shell Molds and Cores		$60
Course No. 6	March 8-10	Birmingham, Ala.
Economical Purchasing of Foundry Materials		$60
Course No. 7	March 27-29	Chicago
Core Practices		$90
Course No. 8	May 22-26	Chicago
Sand Testing		$150
Course No. 9	June 26-30	Detroit
Gating and Risering of Castings		$60
Course No. 10	July 17-19	Chicago
Metallurgy of Gray Iron		$60
Course No. 11	Sept. 13-15	Chicago
Defects—Causes and Remedies		$60
Course No. 12	Oct. 2-4	Chicago
Sand Control and Technology		$60
Course No. 13	Oct. 18-20	Detroit
Cleaning Room Operation		$60
Course No. 14	Nov. 1-3	Chicago
Production Scheduling and Control		$60
Course No. 15	Dec. 4-6	Chicago

Registration is now open. Make reservations for all 1961 AFS-T&RI training courses by course numbers and dates given. Registrations accepted in order as received at AFS Headquarters.

← Circle No. 151, Pages 141-142

Work on the CO_2 process and oxygen setting oils highlighted a recent meeting held at AFS Headquarters by the Sand Division Core Test Committee. A review of CO_2 data from the last work session at the University of Illinois was included in the agenda.

Members of the Ductile Iron Research Committee at recent meeting held at AFS Headquarters. Clockwise are: H. G. Haines, Woodruff & Edwards, Inc., Elgin, Ill.; A. H. Rauch, Deere & Co., Moline, Ill.; H. W. Ruf, Grede Foundries, Inc., Milwaukee.

Also: D. L. Crews, James B. Clow & Sons, Inc., Coshocton, Ohio; W. M. Spear, Worthington Corp., Harrison, N.J.; AFS Technical Director S. C. Massari; and David Matter, Ohio Ferro Alloys Corp., Canton, Ohio.

Members of the Heat Transfer Committee discussed future plans at a recent meeting held at the National Office. Left to right are: W. K. Bock, National Malleable & Steel Castings Co., Cleveland; R. E. Spear, Aluminum Co. of America, Cleveland; J. T. Berry, Armour Research Foundation, Illinois Institute of Technology, Chicago; and AFS Technical Director S. C. Massari.

Plans for the Sand Division technical program at the 1961 Castings Congress were discussed recently by the Executive and Program and Papers Committees. Clockwise are: J. A. Terpenning, Archer-Daniels-Midland Co., Cleveland; R. H. Olmsted, Whitehead Bros., New York; V. Rowell, Archer-Daniels-Midland Co., Cleveland.

Also C. L. Bowman, consultant, Columbus, Ind.; AFS Technical Director S. C. Massari; T. W. Seaton, American Silica Sand Co., Ottawa, Ill.; E. C. Zirzow, Warner G. Smith, Inc., Cleveland; E. J. Passman, Frederic B. Stevens, Inc., Detroit; and N. Sheptak, Dow Metal Products Co., Midland, Mich.

Nominate Society's Officers, Directors

Albert L. Hunt, executive vice-president, Superior Foundry, Inc., Cleveland, has been nominated President of the American Foundrymen's Society to take office next May.

John A. Wagner, president, Wagner Castings Co., Decatur, Ill., was selected as the Society's new Vice-President by the Nominating Committee which met Dec. 12. Both President and Vice-President will serve one-year terms.

The committee also nominated six new National Directors to serve three year terms. Nominated were:

Daniel B. Best, superintendent, Brass & Iron Foundries, Bethlehem Steel Co., Bethlehem, Pa.

Roger J. Hageboeck, vice-president, Frank Foundries Corp., Moline, Ill.

Dale Hall, works manager, Oklahoma Steel Castings Co. Div., American Steel & Pump Corp., Tulsa, Okla.

C. J. Lonnee, president, Alloyed Grairon Castings Corp., Ravenna, Mich.

Charles Ossenfort, foundry superintendent, Fairbanks, Morse Co., Kansas City, Kans.

Carl O. Schopp, assistant general superintendent, Link Belt Co., Indianapolis.

Election of the Society's new officers and directors will take place at the 1961 Convention to be held May 8-12 in San Francisco. Additional nominations can be made up to 45 days prior to the annual meeting on written petition signed by at least 200 members.

Divisions Continue Work on Research

AFS technical committees meet during the year to conduct investigations into all phases of the foundry field. At these meetings, groups review past work and plan future research. Recent sand committee meetings include:

Chapter assignments have been made by the Analysis of Castings Defects Handbook Committee, formerly known as the Controlled Casting Quality Committee.

Activities of the Shell Mold and Core Committee included the *preparation of a questionnaire on dimensional control.*

The Committee on Materials Used in Malleable Foundries is continuing its *work on pin hole porosity.* Initial findings show furnace atmosphere has little effect on its formation.

Editing assignments were made by the Core Test Committee for *test procedures for carbon dioxide sodium silicate core sands* as well as for the *testing of air set binders.*

Cupola Advisor Committee

H. W. Gorman, Allis-Chalmers Mfg. Co., Milwaukee, has succeeded Carl F. Joseph, Central Foundry Div., General Motors Corp., Saginaw, Mich., as chairman. Joseph resigned as chairman after serving a number of years.

The committee at its last meeting recommended that AFS publish a monograph on cupola operating guides.

Members also reviewed the use of the Shaw instrument which makes possible a continuous recording of cupola tapping temperatures; reviewed a film on the production of iron briquetts by direct reduction of iron in a pilot plant, and a film on a German hot-blast cupola.

The committee toured the U. S. Steel Co. Gary Works' coke plant, blast furnaces, and rolling mills.

Ductile Iron Division

A divisional award for the best technical paper will be given at the 1961 Convention. A committee consisting of W. W. Levi, consultant, Radford, Va., K. D. Millis, International Nickel Co., New York, A. H. Rauch, Deere & Co., Moline, Ill., and C. K. Donoho, American Cast Iron Pipe Co., Birmingham, Ala., will consider candidates for the award.

The heat treatment committee has been reorganized and is considering *a study of hardenability as applied to ductile iron when either induction or flame hardened.*

Research committee members are making *an analysis of residual magnesium in iron* and may have a report in the near future with the possibility of presenting it during the 1961 Congress.

Melting for ductile iron has been selected as the theme for the shop course. G. Krumlauf, Republic Steel Corp., Cleveland, Millis, and Rauch will prepare the program in conjunction with the melting comittee.

Malleable Division

Investigations into pinhole porosity are being continued by the Materials Used in Malleable Foundries Committee. Test castings from experiments conducted by the group have been examined. All pinholes were given microscopic examinations by A. H. Zrimsek, Magnet Cove Barium Corp., Arlington Heights, Ill., and Steve Cowen, Wagner Castings Co., Decatur, Ill. Both investigations showed that a sand grain occurred in the pinhole cavity. The pinholes were both smooth and dendritic.

Despite the fact that three different heats were melted under nitrogen, carbon monoxide, and carbon dioxide, there did not appear to be any difference in the prevalence of pinhole porosity.

The committee is now collecting production run samples for study. Each foundry represented on the committee will send three uncleaned samples containing pinholes, broken in the pinhole area.

Foundries contributing samples will keep records of the sand mixture, pouring conditions and melting practice, and have them available if examination of the specimens indicates this information is necessary. In addition to inspecting the samples, photomicrographs will be made of the area.

Wisconsin Regional Conference Feb. 9-10

Latest technical developments will be highlighted at the Wisconsin Regional Conference to be held Feb. 9-10 at the Hotel Schroeder, Milwaukee. The conference is sponsored by the AFS Wisconsin Chapter in cooperation with the University of Wisconsin.

A plant visit will be made Wednesday, Feb. 8, to the Evinrude Motors Co., Milwaukee. Advance registration is required.

Larry Krueger, Pelton Steel Casting Co., is conference chairman; Prof. P. C. Rosenthal, University of Wisconsin, is co-chairman. Howard Voit, Sterling National Industries, is program chairman for the general meetings and Richard Ballmann, General Casting Co., is program chairman of the sectional meetings.

THURSDAY, FEB. 9

(Morning Sessions)

9:00 Registration.

10:00 "The New Emphasis on Materials Research," Associate Dean W. R. Marshall, Jr., University of Wisconsin. "A Look at the Future for AFS," AFS Regional Vice-President H. M. Patton, American Hoist & Derrick Co.

10:50 "New Market Opportunities for Metal Castings," J. H. Schaum, editor, MODERN CASTINGS.

12:00 Luncheon. "You Make the Difference," Bill Gove, Bill Gove Organization.

(2:15 Sectional Meetings)

GRAY IRON—"Heat Treatment of Cast Iron," Marvin Evans, consultant.

STEEL—"Aircraft Quality—What and How," John Varga, Battelle Memorial Institute.

MALLEABLE—"Core Sand Practice for the Malleable Iron Foundry," Don Dalton, Thiem Products.

NON-FERROUS—"New Air Set Cores and Practices," Frank H. Dettore, G. E. Smith Co.

PATTERN—"New Developments in Plastic and Plaster," Stan Munson, Ren Plastics, Inc.

(3:45 Sectional Meetings)

GRAY IRON—"Emission Analysis," Allan Goldblatt, Applied Research Corp.

STEEL—"What's New in Pyrometry?", Douglas Johnson, Barber-Coleman Co.

MALLEABLE—"Molding in a Semi-Mechanized Foundry," Carl Schopp, Link-Belt Co.

NON-FERROUS—"What a Foundry Can Expect with a Plastic Core Binder," Raymond Handwerk, B. F. Goodrich Co.

PATTERN—"Heated Core Box Equipment—What it Means to the Patternshop," H. R. Bilter, International Harvester Co.

6:30 Banquet. "The Impact of Space Technology on the American Economy," Dr. Joseph Shea, A. C. Spark Plug Div., General Motors Corp.

FRIDAY, FEB. 10

(10:00 Sessions)

GRAY IRON—"Reliability as it Pertains to the Foundry," C. E. Drury, Central Foundry Div., General Motors Corp.

STEEL—"Machinability of Steel Castings," Edward J. Wellauer, Falk Corp.

MALLEABLE—"Induction Melting of Malleable Iron," Charles F. Smith, I. F. Mfg. Co.

NON-FERROUS—"Producing Quality Castings," A. B. Steck, Wehr Steel Co.

PATTERN—"The Advancement of Hot Core Boxes and Processes, and What is Ahead for the Soaring 1960s," Ray Sutter, Sutter Products Co.

12:00 Luncheon. "Football—Professional Style," Gary Knafelc, Green Bay Packers.

(2:30 Sessions)

GRAY IRON—"Pneumatic Chip Injection by the Roxy Process," George W. Anselman, Anselman Foundry Services.

STEEL—"Recent Innovations in Steel Molding," Prof. R. W. Heine, University of Wisconsin.

MALLEABLE—"Use of Exothermics on Malleable Iron," Jack W. Giddens, Foundry Services, Inc.

NON-FERROUS—"What's New in Light Metals," C. R. Howle, Aluminum Co. of America.

PATTERN—"Improved Methods for Cast-to-Size Patterns—Shaw Process," R. J. Christensen, Wisconsin Pattern Works.

Stress Production Techniques at Michigan Regional

Business in area varies greatly between busy automotive foundries and independent shops. Foundrymen expect gradual increase in business with new technologies playing an important role in the coming years.

Production discussions took on added significance at the Michigan Regional Foundry Conference held at Saginaw, Mich. The meeting was held in the world's foundry center, site of the largest malleable and gray iron foundries and adjoining the largest permanent mold foundry.

A record 400 foundrymen, attending the meeting, expressed approval of informal group discussions, tried on an experimental basis. Nine basic problems were held under the leadership of industry experts. This open exchange of information on common problems supplemented the technical sessions.

Area business conditions differed radically between captive and independent foundries, a MODERN CASTINGS survey indicated. Production was high at the automotive shops due to the introduction of 1961 models. Independent foundries reported operations off 20 to 30 per cent from normal.

Consumer acceptance of new models in the coming months will determine which captive shops will continue to operate at conference-time capacities. Due to the acceptance of compact cars, it is possible that high tonnage levels of the past will not be exceeded.

Independent foundries look for a gradual recovery during the coming months. No bright spots were reported but area shops expect to hold and increase their share of the fabrication market with improvement of general business conditions.

Critics within the metalcasting industry were reminded by former AFS President, Bruce Simpson, National Engineering Co., of the technical advances made during the past 20 years. He stated that the problem of the industry is not over-production but under-selling; that metalcasters suffer not so much from lack of research as from the lack of coordinated research. Both of these efforts could be vastly improved, said Simpson, by a centralized, industry-wide program. Duplications and overlapping of activities by the 20 groups representing the industry has diluted the returns to the detriment of all segments, he observed.

The keen interest of the Conferees was aroused in the latest technology of furfural binders. In the informal groups this was explored in the ferrous sands group, the session on dies, molds and patterns, and shell molding.

T. B. Pfaff, Pontiac Motor Car Div., General Motors Corp., in one of the best attended meetings, told of Pontiac's progress on the development of furfural cores. The process does all that the shell core system does and provides controlled collapsibility said Pfaff.

Thousands of various production castings have been made with excellent finish, good shakeout characteristics, and elimination of pinholes. Details were not revealed but Pfaff indicated that Pontiac had made considerable, but unannounced, advances recently. Pontiac is also developing equipment to take advantages of the fast curing rates—a 2 to 3 second cycle.

Expanding production in automotive die casting and permanent molding was predicted by L. Axford, Ford Motor Co. and S. Strong, AC Spark Plug Div., General Motors Corp. Axford discussed permanent mold and die casting processes. He pointed out that metal specifications and product design are the determining factors when considering either process.

Die casting magnesium parts at AC Spark Plug has grown continually since initial investigations in the 1950's. Currently castings weighing up to 4-1/2 lbs and of considerable dimensions are being cast. Eight cold chamber magnesium die casting machines ranging in capacity from 100 to 2000 tons locking pressures are being used and facilities will be expanded.

AC experience rates zinc, aluminum, and magnesium castings as follows (1, most favorable; 3, least favorable):

	Zn	Al	Mg
Material Cost (by volume)	3	2	1
Die Cast Labor Cost	2	3	1
Die Replacement Cost	1	3	2
Melting & Refining Cost	1	2	3
Finishing Cost (Ornamental Castings)	1	2	3
Finishing Cost (Functional Castings)	2	1	3
Machining Cost	2	3	1
Shipping Cost	3	2	1

Conference leaders congratulate banquet speaker W. S. Sheehan, center. Others are George Frye, Saginaw Chapter Chairman; Conference Chairman V. J. Sadler; Program Chairman J. R. Young; and Publicity Chairman Jess Toth. (Saginaw News Photo).

Can castings be sold to the aircraft industry? Yes, said Harry Gravlin, Hamilton Standard Div., United Aircraft Corp., and formerly assistant general manager, parts and equipment manufacturing division, Chrysler Corp. The aircraft industry greatly needs the support of small foundries, he stated, especially where flexibility is essential and production runs are small.

A large updating program is continually in operation to bring military aircraft in line with the latest improvements. This represents millions of dollars in business for the metal-casting industry, particularly in short runs and frequent configuration changes.

In showing typical aircraft castings, Gravlin noted that quality requirements are strict but are within the range of foundries exercising effective control measures.

He predicted a greater use of stainless steel castings in new aircraft, particularly in the new B-70, supersonic, high altitude model.

Fundamentals of casting design were presented in an illustrated talk by J. Flitz, Central Foundry Div., General Motors Corp. He stressed the importance of keeping the cost of the finished product to a minimum while satisfactorily performing its function.

Among his recommendations on design were: avoid sharp corners; eliminate heavy, isolated sections; eliminate cores where possible; and combine more than one finished part into a single casting where feasible.

Weight reduction, particularly in the automotive field, is receiving particular emphasis. Three methods were advanced:

1. Reduction of physical dimensions through engineering and redesign.

2. Conversion from ferrous to light metals.

3. Conversion from low of medium strength ferrous metals to higher strength metal.

T. B. Pfaff, with glasses, created much interest with his talk on furfural binders. Informal discussion followed his speech.

W. D. McMillan, MODERN CASTINGS contributing editor, uses board to illustrate a point in his discussion on ductile iron.

Automated sand systems were advocated by Randolph Dietert, Harry W. Dietert Co., as a means of meeting increased competition and rising costs through greater control and improved quality. Recent improvements in electronics has simplified design and maintenance of automatic control systems, he said.

Extensive investigations into all aspects of manufacturing, marketing, maintenance, plus outlining basic objectives pay big dividends in constructing multi-million dollar foundries. J. W. Nuss, American Radiator & Standard Sanitary Corp., and Eric Welander, John Deere Malleable Works, related their experiences in constructing new foundries.

Recommendations by Nuss included; consult with supervisor personnel in considering equipment; purchase on the basis of actual equipment needs and not on price; visit other foundries; use unitized engineering and installation where possible, and provide equipment to notify and pinpoint malfunction's instantly.

Welander recommended an analysis of requirements for the predictable future including a careful study of trends and developments in the industry and general economy. The central feature of the Deere ductile foundry is the automatic molding unit which produces 90 molds per hour. Molds are produced on a jolt-squeeze type machine using a swinging pattern turret to permit production of both cope and drag on the same machine.

Other technical talks were given by W. McMillan, Ohio Ferro Alloys Corp., who spoke on ductile iron; and T. E. Barlow, Eastern Clay Products Dept., International & Minerals Corp., and H. R. Fisher, Grand Rapids Foundry Co., who discussed the CO_2 process.

Other speakers and their subjects were: "Brief Review of National AFS Events," AFS Secretary A. B. Sinnett; "What to do if Your Foundry Catches Fire," D. N. Duncanson, Western Adjustment & Inspection Co.; Eisenhower and Personal Diplomacy," William Sheehan; "Career Opportunities in the Foundry Industry," AFS Education Director R. E. Betterley; and "The Foundry of the Future," B. L. Simpson, National Engineering Co.

The conference was sponsored by the AFS Saginaw Valley, Central Michigan, Detroit, and the Western Michigan Chapters with the student chapters of the University of Michigan and Michigan State University.

V. J. Sadler, General Foundry & Mfg. Co., was general chairman. Others were: Vice-Chairman, J. R. Young, Cadillac Motor Car Div., GMC; Secretary, John DeGroot, Alloy Metal Abrasive Co.; Treasurer, Frank Buike, Almont Mfg. Co.; and Publicity Chairman, Jess Toth, Harry W. Dietert Co.

A highly successful portion of the Michigan Conference were the various informal discussion groups. Conferees voted to again present this interchange of problems and solutions at the next conference. H. H. Wilder, is the discussion leader. (Photos by J. R. Fraker).

CHAPTER NEWS

DETROIT—Metallurgical and engineering students recently were chapter guests. Schools represented were University of Detroit, Lawrence Institute of Technology, Wayne State University, and Henry Ford College.

MICHIANA—Standard laboratory equipment is sufficient to solve foundry sand problems, stated J. S. Schumacher, Hill & Griffith Co., Cincinnati.

He called for the detective approach to explore each clew. Shown are Chapter Chairman Walter Ostrowski, Wheelabrator Corp., speaker Schumacher and Vice-Chairman Vern Compton, LaPorte Foundry Co.—by Robert P. Clark

WENTWORTH INSTITUTE—Student Chapter officers are: Chairman Ronald Mafera; James Lochhead; Secretary Leroy Frendberg; and Treasurer Dennis Moore.—by Leroy Frendberg

CHICAGO—Each of the chapter meetings is well attended by Prof. Roy W. Schroeder's University of Illinois students. Congratulating student Robert Kartman is Bert Troy, National Engineering Co. On right is Jerry Austin, Burnside Steel Foundry Co.—by George DiSylvestro.

CENTRAL INDIANA—Going over future chapter program are Carl Schopp, Link-Belt Co., James Barret, National Malleable & Steel Castings Co., and A. R. Downey, International Harvester Co., all of Indianapolis.—by W. R. Patrick

Utah Chapter

Direct Reduction Process

Production of molten metal from ore without use of the blast furnace was discussed by Harvey King, Jr., Pacific States Cast Iron Pipe Co.

The D-L-M process uses a combination of sintering machine, pelletizing, and electric furnace. Fine iron ore is mixed with coal and limestone, pelletized and fed into a sintering machine where partial reduction takes place. The sintering machine discharges the self-fluxing, self-reducing pellets at approximately 1500 F. to the electric furnace for final reduction.

A single unit D-L-M plant produces about 500 tons of pig iron daily; several units can be used together if additional production is needed. A complete unit costs between six and seven million dollars, representing a capital investment of $35 a net ton compared to blast furnace cost of approximately $90 per net ton.

It was predicted that the process will become an essential part of the metal producing industry but is not expected to replace existing blast furnaces.—by J. M. Bushnell

Wentworth Student Chapter

Conducts Active Program

An active program has been initiated by the student chapter. Four students participated in the New England Regional Foundry Conference.

Charles Christadoro presided as co-chairman of a non-ferrous session, Frank Boyda, James Lochhead, and Richard Ishkanian, served as co-chairmen of three general sessions. Students were able to learn the latest methods, operations, and techniques practiced in industry.

At a recent meeting Prof. Edward Bowman, Massachusetts Institute of Technology, explained various phases of industrial management in the foundry. He covered such items as cost, quality control, time study, work planning, purchasing, and labor-management relations.—by Leroy Fredberg and Richard Ishkanian

Western New York Chapter

Challenges to Foundries

During the next decade foundries must face a serious challenge, stated Elmer E. Braun, Central Foundry Div., GMC. He recommended a more extensive study of foundry controls, manufacturing costs, product reliability, marketing techniques, and management tools.—by Don Kreuder

Clemson Gets Books, Foundry Equipment

Foundry instruction at Clemson College, Clemson, S.C., has been improved through recent contributions of a small cupola, pig mold machine, and complete set of AFS books.

A small warm blast cupola was donated by North State Pyrophyllite Co., Greensboro, N.C. The cupola is lined to a 12-inch inside diameter. It has six upper tuyeres with a 3/4-inch inside diameter and six lower tuyeres with a 1-inch inside diameter. A special feature is the utilization of heat for warming the incoming blast accomplished through tubes imbedded in the refractory lining.

The cupola has an operating time of 53 minutes using an iron to coke ratio of 10:1 and 3/4x1 inch coke. The charge is made up of 15 lb pig iron, 15 lb textile scrap, 2-1/2 per cent limestone, and 1 per cent ferro carbon addition.

Caroline Foundry & Machine Co., Spartanburg, S.C., donated the pig mold machine. It makes pigs approximately 1-1/3x2-1/2x4 inches.

A complete set of AFS publications was donated to the school by the AFS Piedmont Chapter. The books will be turned over to the general library of the college.

At Clemson College, the foundry laboratory and classroom instructions are part of the manufacturing process division of the Industrial Engineering Department. The metallurgy department, headed by Dr. McCormack, is part of the chemical engineering department.

During the year about 800 freshman engineering students receive foundry instructions and use the foundry laboratory. Advanced classes in foundry practice and research start the second semester. Courses in fundamentals of metallurgy and metallurgy of cast metals are taught in the chemical engineering department to industrial, chemical, and mechanical engineering students.

Piedmont Chapter donates set of AFS publications to Clemson College. Left to right: Chairman Richford Hanner, Queen City Foundry Inc., Everett Laitala, head of the college's Industrial Engineering Department; Prof. J. H. Couch.

Also: Prof. Thomas Reid; Dr. J. T. McCormach; and Chapter Vice-Chairman Stephen Richard, Richard Foundry Corp.

Present at the donation of a small warm blast cupola and pig mold machine to Clemson College are, standing: Prof. J. H. Couch, Clemson College; Fred Barbour, Republic Steel Corp.; Jack Williams, Kerchner Marshall & Co.; Robert Deal, Republic Steel Corp.; and Warren Fraser, Beardsley & Piper Corp.

Kneeling are: John Lamar Reeves, Carolina Foundry & Machine Co., Robert Hoover, and Jeff Jeffries, both of North State Pyrophyllite Co.

Canton Chapter

Profitable Foundry Operations

Methods and techniques used in cost analysis surveys for improving foundry operations were explained by Harry Figgie, Jr., Booz, Allen & Hamilton Co., at the annual management night. Data on operations, foundry trends, and how they can be adapted for profitable operations were on agenda. Areas for improvement were outlined.—by Charles Stroup

Central Illinois

Young Engineers in Industry

Guides for young engineers entering the metalcasting industry were supplied by Robert Jacoby, St. Louis Coke & Foundry Supply Co. Particular emphasis was placed on seeking counsel from long-term industry men. Forty-eight University of Illinois Engineering students, accompanied by Prof. Charles Phipps, were guests of the chapter.—by Charles W. Search

Southern Tier Section

Modernizing Small Foundries

Over-all planning is necessary for the modernization of small foundries and may be achieved in a step-by-step procedure, were observations by O. H. Kraft, Nomad Equipment Corp., Milwaukee.

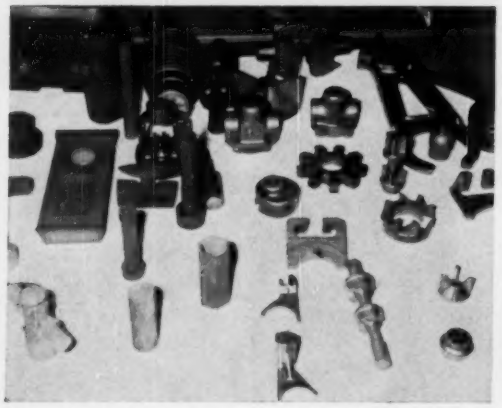
AFS National Director Donald Webster spoke on the group's efforts to establish a separate chapter.—by Francis H. Troy

WESTERN NEW YORK—Attending a recent chapter meeting were Jules Hubble, Chevrolet Grey Iron Foundry; Al Diebold, Atlas Steel Castings Co.; Jane Mac Taggart, Samuel Greenfield Co.; and Robert Forrest, Frontier Bronze Corp.—by Don Kreuder

CENTRAL INDIANA—Checking on the chapter's bulletin boards dealing with quality control are Robert Hartpence, Joe Roach, and R. H. Brookes, Link-Belt Co., Indianapolis, and Chapter Chairman T. E. Smith, Central Foundry Div., GMC., Danville, Ill.—by W. R. Patrick

PHILADELPHIA—Participating in the annual "William B. Coleman Night" are Technical Chairman Warren Brown, speaker William C. Hale, Mrs. W. B. Coleman, and Vice-Chairman Robert C. Stokes.—by Leo Houser and E. C. Klank

WENTWORTH INSTITUTE—Students attending the recent New England Regional Foundry Conference were: Richard Ishkanian, James Lochhead, Frank Boyda, and Charles Christadoro—by Richard Ishkanian



TRI-STATE—Shell mold castings produced by Oklahoma Steel Castings Co. Dale W. Davis explained principles of process, covering pattern equipment and rigging, operating temperatures, release agents, molding refractories, resins, curing, investment time, ejection, and assembly for pouring.—by Bobby Bell

Western Michigan Chapter

Effective Sand Testing

Extensive and practical sand control is possible in most foundries, said Joseph Schumacher, Hill & Griffith Co., Cincinnati.

Schumacher emphasized the importance of ramming mold hardness and its effect on casting dimension and stated that sand is just as sensitive to screen analysis changes as to moisture changes. An important phase of laboratory evaluation are the physical properties found in the mold at variance from the standard AFS testing. The speaker said that foundrymen could improve casting quality and cut scrap losses through improved laboratory techniques.—by J. R. McNamara

Texas Chapter

Shell Core Trends

The continued increasing popularity of shell cores is expected to be further increased with new resins now being developed, Herbert von Wolff, Shalco Div., National Acme Co., told Texas foundrymen.

Advantages include: reduced tooling cost and scrap, elimination of core ovens, use of limited floor space, use of unskilled labor, achieving close tolerances, good storage characteristics, and easier handling due to light weight. Shell cores are adaptable to all sizes and types of metal. Zircon sands are used in shell cores and molds and shell sands can be satisfactorily reclaimed when isolated from regular molding sands.—by C. Eugene Silver

Piedmont Chapter

Aluminum Casting Defects

Internal defects in aluminum castings were divided into three classes by D. L. LaVelle, Federated Metals Div., American Smelting & Refining Co.

These are porosity, non-metallic inclusions, and gas. Porosity problems may be caused by trapped air, gas and shrinkage. Inclusions may be subdivided into oxides, dross, and flux. Gas problems revolve chiefly around hydrogen.

LaVelle recommended square rather than rounded down sprues and rectangular gating systems. Sprues should be kept full and ladles kept as close to openings as possible. He also advised use of small sprues or chokes in the runner system.

Melting should be as simple as possible, pouring from the same crucible in which the melting is done. If a tilting furnace is used, hold the

pouring ladle as close to the spout as possible.

Multiple gating systems were advocated as a method of combating shrinkage with runners in the cope and ingates in the drag. LaVelle noted that heavy sections must have directional solidification. Chills are often necessary and insulated risers and plastic sleeves can be used to advantage.

In discussing the gas problem, LaVelle stated that hydrogen can be reremoved by bubbling nitrogen or chlorine through the melt. Degassing should be done when the melt temperature is falling.

Plant visits were made to Bahan Textile & Machinery Co., Steel Heddle Mfg. Co., and Eagle Iron Works. —by Larson E. Wile

Wisconsin Chapter

Savings With Modernization

Savings of 80 to 90 per cent in materials handling can be achieved by eliminating loose handling through unitization or palletization, stated J. H. Bates, Allis-Chalmers Mfg. Co.

Bates also recommended a thorough study of storage areas, equipment, and plant layout so that standardization can be accomplished on unitized loads. Coordination between foundries, their suppliers, and customers will also aid in eliminating unnecessary handling.

Seventy per cent of all injuries occur away from the place of employment, pointed out Michael Mincardi, Allis-Chalmers Mfg. Co. These injuries represent a loss to the company of the employee's service and make it imperative that safety programs be expanded to cover activities off the job.

R. A. Baumgardt, International Harvester Co., described his company's procedures in purchasing patterns. He also spoke on the patternmakers responsibility regarding pattern functions, materials used, and new methods of molding and coremaking. In general, Baumgardt feels that during the past ten years pattern shops have offered less in services.

Central New York Chapter

Benefits from AFS

Participation in AFS activities will bring rewards to AFS members, stated General Manager Wm. W. Maloney. He recommended that foundrymen serve on local and technical committees and attend courses sponsored by the Research & Training Institute.—by Anthony F. Izzo

PHILADELPHIA — Discussing point prior to talk on "Penetration and Veining Tendencies of Cores" are Chapter Chairman R. C. Stokes, Crown Non-Ferrous Co.; speaker George DiSylvestro, American Colloid Co., Skokie, Ill.; and Technical Chairman Stewart Wick, New Jersey Silica Sand Co.—by Leo Houser and E. C. Klank

MICHIANA—Ferrous and and non-ferrous sessions were conducted recently. J. R. Lowry, Steel Sales Co., left, spoke on alloyed gray iron castings. Ray Cochran, R. Lavin & Sons, right, discussed bronze melting practice. In center is Walter Ostrowski, Wheelabrator Corp., chapter chairman—by Robert P. Clark

DETROIT—Three generations attended a recent chapter meeting. Left to right are; Joseph C. Metyko, retired, holder of an AFS life membership; his son Jacob; and grandson Kris.—by Jess Toth

DETROIT—Past chairmen at a recent meeting include rear row: Claire Crawford, Michael Warchol, and Jess Toth. In the front row: Vaughn C. Reid, Grant Whitehead, Clifford Hockman, Vaughn Reid, and William Yaw. The Reids are father and son.—by Jess Toth

WESTERN MICHIGAN—How to more effectively use existing sand testing facilities was explained by J. S. Schumacher, Hill & Griffith Co., second from left.

Others are: Al Jacobson, Sr., Grand Haven Brass Co.; C. J. Lonee, Alloyed Grairon Castings Co.; R. Williams, Campbell Wyant & Cannon; and C. Cousineau, Carpenter Bros.—by K. C. McCready

CENTRAL NEW YORK—AFS General Manager Wm. W. Maloney with portfolio awarded by chapter. Chapter Chairman Robert Watson, Chicago Pneumatic Co., is on left.—by Anthony F. Izzo

PHILADELPHIA—Chapter Chairman Robert C. Stokes, Crown Non-Ferrous Foundry Co., presents AFS certificate of achievement to Membership Chairman Fred T. Schaeffer, Philadelphia Coke Co.—by Leo Houser and E. C. Klank

TEXAS—Technical Chairman Jake L. Maenza, Dee Brass Foundry, listens intently as Herbert von Wolff, Shalco Div., National Acme Co., discusses shell cores and new trends. —by C. Eugene Silver

CENTRAL OHIO—The importance of foundries making quality castings and improving the liaison between customers and the shop was emphasized by W. G. Ferrell, left, retired.

He observed that since there is no grain flow, castings have a unique advantage of uniform strength in all directions. This advantage must be exploited. On right is Chapter Secretary R. E. Moore, Zirkle Pattern Works, Inc., Springfield, Ohio.—by Joseph A. Riley, Jr.

CHICAGO—Winner of the chapter's recent drawing is W. J. Urbanek, Kensington Steel Co., left. Chapter Chairman Don Meves, American Steel Foundries, offers congratulations.—by George DiSylvestro

PHILADELPHIA—Former Chapter Chairman T. R. Walker, Jr., right, presents certificate of appreciation to 1959-60 Chapter Chairman E. A. Zeeb.—by Leo Houser and E. C. Klank

NORTHWESTERN PENNSYLVANIA—The role of refractories in the future of iron and steel was explained by W. N. Butterworth, General Refractories Co., Cleveland.—by Walter Napp

Stresses Improving Foundry Courses

How foundry courses in industrial arts schools can be improved was explained by AFS Education Director R. E. Betterley at the Stout State College annual industrial arts conference at Menomonie, Wis.

Betterley, a former Stout Industrial Education professor, discussed

AFS Education Director R. E. Betterley shows casting techniques at industrial arts conference.

"Foundry Today—Suggestions for Units in School Shops." He was assisted by Wesley Face, Stout foundry instructor, who demonstrated the CO_2 process.

The cast metals sessions were supplemented with the AFS film "Cast Metals and You," samples of school-shop castings, CO_2 cores, molds, and shell molds. Kits of AFS educational literature on cast metals instructions were presented to participants.

The conference was attended by 175 teachers, directors, and supervisors of industrial education in Wisconsin, Minnesota, Iowa, Michigan, South Dakota, Illinois, and Wisconsin.

Washington Chapter

Vacuum Metal Melting

Recent developments in vacuum arc melting allow increasingly pure metal, A. J. Kiesler, General Electric Co., told area foundrymen. Some of the melting processes are time consuming and complicated but the purity assures their sale.—by Jim McComb

Southern California Chapter

Begins Technical Sessions

A diversified program has initiated the chapter's technical program. H. J. Weber, AFS Director of Safety, Hy-

giene and Air Pollution, stated that the control of radiant heat is a major factor contributing to the comfort of foundry workers. He suggested greater use of aluminum sheathing, aluminum paint, and woven aluminum clothing.

J. H. Kimes, Tennessee Products & Chemical Corp., presented fundamentals of cupola practice, and recommended that foundries be less reluctant to experiment in if they are experiencing melting problems.

Common defects in casting aluminum and causes were presented by D. L. LaVelle, American Smelting & Refining Co. Examples of defects caused by porosity and inclusions were shown followed by suggestions for correction.—by K. F. Sheckler

Cincinnati Chapter

Patternmakers and the Future

Patternmakers have a great future in the expanding foundry business, but only if they become progressive, warned Eyvind A. Larsen, Dayton Steel Foundry Co.

Larsen reminded patternmakers that they could not be passive in relations with foundrymen. Instead, they must follow through on orders and become trouble shooters for customers.

Foundrymen too must share a portion of the blame, said Larsen. Too often, he pointed out, patternmakers are not consulted by foundries, only briefed.—by J. L. Shinn

San Antonio Section

Movies Stress Fundamentals

Use of photo elastic studies in obtaining better joining of castings and weldments and steel casting design were demonstrated through movies.

The steel castings film showed operations from the drawing board to the finished product, stressing the need for cooperation in all departments to produce high quality castings.

Proper methods of welding were shown through the use of experiments. Use of photo elastic studies defined the areas of stress and strain prior to failure. The effect of proper design on various sections were also demonstrated. The film illustrated the recommended techniques on a wide range of casting sizes and configurations.—by Frank Page

ST. LOUIS—Furan binder systems were discussed by Anton Dorfmueller, Jr., Archer-Daniels-Midland Co., Cleveland. Advantages, disadvantages and possible future uses were covered.—by W. E. Fecht

WISCONSIN—Hot tears in malleable iron castings are analyzed by Prof. R. W. Heine, University of Wisconsin, Madison, Wis.—by Bob DeBroux

PIEDMONT—Aluminum casting defects and their corrections were explained at a recent meeting. Left to right: speaker D. L. LaVelle, Federated Metals Div., American Smelting & Refining Co.; Chairman, R. J. Hanner, Queen City Foundry Co.; Dr. J. T. McCormach, Head of Metallurgical Dept., Clemson College.

Also: Vice-Chairman S. W. Richard, Richards Foundry Corp.; Arrangements Chairman, J. W. Harris, Eagle Iron Works; and Membership Chairman Warren Fraser, Beardsley & Piper Co.

SOUTHERN CALIFORNIA—Causes and cures of aluminum casting problems are explained by Donald LaVelle, American Smelting & Refining Co.—K. F. Sheckler

UTAH—Chapter officers and participants at a recent meeting include Don Rosenblatt, American Foundry & Machine Co. Div., Eimco Corp.; Chapter Director Byron R. MacKay, Lake Metals Co.; Chapter 1st Vice-President Spencer Phillips, Ohio Ferro Alloys Corp., guest speaker.

Also Arthur Falk, AFS National Director; Everett Backman, Backman Foundry Co., Chapter Chairman; Martin Larsen, Utah Foundry Supply Co., technical chairman.—by J. M. Bushnell

TRI-STATE—Principles of shell molding process were presented by Dale W. Davis, right, Oklahoma Steel Castings Co. On left is James Pacus, Acme Foundry & Machine Co.—by Bobby Bell

AFS Chapter Meetings

JANUARY

Birmingham District . . Jan. 13 . . Thomas Jefferson Hotel, Birmingham, Ala. . . W. R. Bond, Woodward Iron Co., *Management Night.*

British Columbia . . Jan. 20 . . Lougheed Hotel, Vancouver, B. C. . . R. J. Mulligan, Archer-Daniels-Midland Co., *"Which Core Process?"*

Canton District . . Jan. 5 . . Brookside Country Club, Barberton, Ohio . . *Panel.*

Central Illinois . . Jan. 9 . . Vonachen's Junction, Peoria, Ill. . . C. A. Sanders, American Colloid Co., *"A Look at Future Foundries."*

Central Indiana . . Jan. 9 . . Athenaeum Club, Indianapolis . . R. W. Ruddle, Foundry Service, Inc., *"Solidification of Metals."*

Central Michigan . . Jan. 18 . . Hart Hotel, Battle Creek.

Central New York-Southern Tier Section . . Jan. 20 . . Hickory House, Horseheads, N. Y. . . N. P. Lillybeck, Modern Equipment Co., *"Cupola Practice."*

Central Ohio . . Jan. 14 . . Lincoln Lodge, Columbus, Ohio . . *Winter Party.*

Chesapeake . . Jan 14 . . American Legion Hall, Parkville, Md. . . Oyster Roast Jan. 27 . . Baltimore Engineers Club, Baltimore, Md. . . J. J. O'Brien, Foundry Core Supply Co., *"Shell Cores."*

Chicago . . Jan. 9 . . Chicago Bar Association, Chicago . . *Past Presidents' Night.*

Cincinnati District . . Jan. 9 . . Wigwam Restaurant, Cincinnati.

Connecticut . . Jan. 24 . . Waverly Inn, Cheshire, Conn. . . R. B. Fischer, Ingersoll Rand Corp., *"Gating & Risering in the Foundry."*

Detroit . . Jan. 19 . . Wolverine Hotel, Detroit . . E. Crimmens, Kelsey-Hayes Co., *Film, Kelsey-Hayes Foundry Operations.*

Eastern Canada . . Jan. 13 . . Sheraton Mount Royal Hotel, Montreal, Que. . . Round Table Discussion, Discussion Leaders: *Cast Iron*: J. C. Kinsella, Canada Iron Foundries, Ltd., *Steel*: M. O. Diorio, Dominion Brake Shoe Co. Ltd., *Non-Ferrous*: J. Dick, Montreal Bronze.

Eastern New York . . Jan. 17 . . Panetta's Restaurant, Menands, N. Y.

Metropolitan . . Jan. 9 . . Military Park Hotel, Newark, N. J. . . G. M. Etherington, American Brake Shoe Co., *"Shell Cores"*, G. N. Davis, Cooper Alloy Corp., *"CO_2 Cores"*, R. M. Overstrud, Reichhold Chemical Industries, *"Quality Castings Through Modern Core Practices."*

Michiana . . Jan. 9 . . Club Normandie, Mishawka, Ind. . . Edward C. Mathis, Pickands Mather Co., *"Cupola Melting Practice"*, F. L. Riddell, H. Kramer & Co., *"Metallurgical Control in the Brass Foundry."*

Mid-South . . Jan. 13 . . Claridge Hotel, Memphis, Tenn. . . D. Gerlinger, Milwaukee Foundry Equipment Co., *"Pressure Molding."*

Mo-Kan . . Jan. 19 . . Fairfax Airport, Kansas City, Kan. . . G. Koren, Beardsley & Piper, *"What Shell Sand Coating Process and Why Shell Cores."*

Northeastern Ohio . . Jan. 12 . . Manger, Hotel, Cleveland . . Prof. L. Lawrence, Alfred University, *"Characteristics of Foundry Sands and Bonding Agents."* (First of Symposium Series) . . **Case Institute of Technology: Jan. 19 . .** *"Mixing and Compacting Foundry Molding Sands"* . . **Jan. 26 . .** *"Core Binders and Core Processes."*

Northern California . . Jan. 16 . . Spenger's Fish Grotto, Berkeley, Calif. . . R. J. Mulligan, Archer-Daniels-Midland Co., *"Which Core Process?"*

Northern Illinois & Southern Wisconsin . . Jan. 10 . . Rockford Country Club, Rockford, Ill. . . W. R. Jaeschke, Whiting Corp., *"Cupola Operation."*

Northwestern Pennsylvania . . Jan. 23 . . Amity Inn, Erie, Pa. . . Lester B. Knight, Lester B. Knight & Associates, *"Mechanization and Modern Foundry Practice."*

Ontario . . Jan. 20 . . Seaway Hotel, Toronto . . D. L. Watson, Galt Brass Co., and W. R. Moggridge, Canada Iron Foundries, Ltd., *"The Foundry Industry and Quality Control."*

Oregon . . Jan. 18 . . Heathman Hotel, Portland, Ore.

Philadelphia . . Jan. 13 . . Engineers' Club, Philadelphia . . R. Lash, Lebanon Steel Foundry, *"Modern Cleaning Techniques."*

Piedmont . . Jan. 13 . . Virginian Hotel, Lynchburg, Va. . . T. Barlow, International Minerals and Chemical Co., Eastern Clay Products Div., *"Castings Defects as Related to Sand Practice."*

Pittsburgh . . Jan. 16 . . Hotel Webster Hall, Pittsburgh, Pa. . . S. F. Carter, American Cast Iron Pipe Co., *"Electric Furnace Practice for Steel Castings."*

Quad City . . Jan. 16 . . Le Claire Hotel, Moline, Ill. . . *Panel Discussion.*

Rochester . . Jan. 3 . . Manger Hotel, Rochester, N. Y. . . F. W. Less, Hooker Chemical Corp., Durez Plastics Div., *"Resin Coated Sand and Its Fundamentals."*

Saginaw Valley . . Jan. 5 . . Fischer's Hotel, Frankenmuth, Mich. . . W. Putnik, Chev. Saginaw Grey Iron Foundry Div., R. Harrison, Saginaw Malleable Iron, D. Des Jardins, Eaton Manufacturing Co., *"Material Handling in Saginaw Valley Foundries."*

St. Louis District . . Jan. 12 . . Edmonds Restaurant, St. Louis . . R. T. Lewis, Keen Foundry Co., *"Are Your Costs Reliable."*

Southern California . . Jan. 13 . . Rodger Young Auditorium, Los Angeles . . R. J. Mulligan, Archer-Daniels-Midland Co., *"Which Core Process?"*

Tennessee . . Jan. 27 . . Wimberly Inn, Chattanooga, Tenn. . . W. A. Hambley, Chas. A. Krause Milling Company, *"Gray Iron Foundry-Sand Practice."*

Texas . . Jan. 20 . . Baker Hotel, Dallas, Texas . . C. F. Lewis, Cook Heat Treating Co., *"Fundamentals of Heat Treatment."*

Timberline . . Jan. 18 . . Oxford Hotel, Denver . . H. L. Mead, Miller & Co., *"The Magic Stove."*

Toledo . . Jan. 4 . . Heatherdowns Country Club, Toledo, Ohio . . H. Henderson, Ren Plastics Co., *"Plastic Patterns vs Aluminum Pattern."*

Tri-State . . Jan. 13 . . Ramada Inn, Tulsa, Okla. . . J. Dee, Dee Brass Foundry, *"Current Trends in Brass Casting Industry."*

Twin City . . Jan. 10 . . Jax Cafe, Minneapolis . . G. L. Armstrong, U. S. Reduction Co., *"Aluminum Gating and Feeding Practice."*

Utah . . Jan. 23 . . Salt Lake City . . R. J. Mulligan, Archer-Daniels-Midland Co., *"Which Core Process?"*

Western Michigan . . Jan. 6 . . Spring Lake Country Club, Grand Haven, Mich. . . *Plant Visitation, Grand Haven Brass Co. Movie on "Taconite."*

Western New York . . Jan. 6 . . Sheraton Hotel, Buffalo, N. Y. . . F. W. Less, Hooker Chemical Co., *"Resin Coated Sand."*

Wisconsin . . Jan. 13 . . Hotel Schroeder, Milwaukee . . N. N. Amrhein, Moderator, Federal Malleable Co. Panel Members: Robert Eck, Eck Foundries, George Antonic, Motor Castings Co., E. Gibson, Grede Foundries, Inc., *"Practical Aspects of Quality Control." General Meeting.*

FEBRUARY

Birmingham District . . *See Southeastern Regional Conference.*

Canton District . . Feb. 2 . . American

Legion, Massillon, Ohio . . J. Morgan, Foresco Co., *"Exothermics"*.

Central Illinois . . Feb. 6 . . Vonachen's Junction, Peoria, Ill. . . C. E. Wenninger, Beardsley & Piper, *"Digging Into Sand Fundamentals."*

Central Indiana . . Feb. 6 . . Athenaeum Club, Indianapolis . . G. W. Anselman, Anselman Foundry Services, Inc., *"New European Techniques." Student's Night.*

Central Ohio . . Feb. 13 . . Seneca Hotel, Columbus, Ohio . . J. B. Caine, Foundry Consultant, *"Cast vs Wrought Materials."*

Chesapeake . . Feb. 24 . . Baltimore Engineers Club, Balitimore, Md. . . L. A. Gardner, Pangborn Corp., *"Foundry of Tomorrow."*

Chicago . . Feb. 6 . . Chicago Bar Association, Chicago . . G. Koren, Beardsley & Piper Div. of Pettibone Mulliken Corp., *"Shell Molding and Coring Equipment."*

Cincinnati District . . Feb. 13 . . Eaton Manor, Hamilton, Ohio.

Connecticut . . Feb. 28 . . Waverly Inn, Cheshire, Conn. . . F. Yrigoyen, Curtis-Wright Metals Processing Div., *"Shell Molding & Shell Cores."*

Detroit . . Feb. 16 . . Pontiac Motor Co. Foundry Division, *Tour of Foundry Operations.*

Eastern Canada . . Feb. 10 . . Sheraton Mount-Royal Hotel, Montreal, Que. . . *Past Chairmen's Night.*

Eastern New York . . Feb. 20 . . Panetta's Restaurant, Menands, N. Y.

Metropolitan . . Feb. 6 . . Military Park Hotel, Newark, N. J. . . Old Timers' Night . . *"Reduce Downtime Through Preventive Maintenance."*

Michiana . . Feb. 13 . . Club Normandy, Mishawaka, Ind. . . A. B. Sinnett, American Foundrymen's Society, *Talk and Film Plus Presentation to Past Chairman.*

Mid-South . . Feb. 10 . . Hotel Claridge, Memphis, Tenn. . . R. A. Colton, Federated Metals Corp., *"Non-Ferrous Metals."*

Mo-Kan . . Feb. 16 . . Fairfax Airport, Kansas City, Kan. . . D. L. Colwell, Apex Smelting Co. . . *"Melting, Casting and Properties of Aluminum."*

Northeastern Ohio . . Feb. 2 . . Case Institute of Technology . . *"How Foundry Sands Affect Casting Surfaces."* . . **Feb. 4** . . Manger Hotel, Cleveland . . *Ladies Night.*

Northern California . . Feb. 13 . . Spenger's Fish Grotto, Berkeley, Calif., J. H. Kimes, Jr., Tennessee Products Chemical Corp., *"Ductile Iron vs Weldments & Forgings."*

Northern Illinois & Southern Wisconsin . . Feb. 14 . . Frontier Inn, Rockton, Ill. . . D. Matter, Ohio Ferro-Alloy Corp. . . *"Ductile Iron."*

Northwestern Pennsylvania . . Feb. 27 . . Amity Inn, Erie, Pa. . . D. L. La Velle, American Smelting & Refining Co., *"Understanding Mechanical Properties and Diagnosing Rejections."*

Ontario . . Feb. 24 . . Seaway Hotel, Toronto . . D. R. Abbey, *"Safety—Foundry Frills, Fantasies and Facts."* R. E. Crowe, Crowe Foundry Ltd., *"Customer Service."*

Oregon . . Feb. 15 . . Park Heathman Hotel, Portland, Ore.

Philadelphia . . Feb. 10 . . Engineer's Club, Philadelphia . . G. Koren, *"Resin Sand—Shell Cores."*

Pittsburgh . . Feb. 20 . . Hotel Webster Hall, Pittsburgh, Pa. . . G. M. Etherington, American Brake Shoe Co., *"Shell Cores."*

Rochester . . Feb. 13 . . Chamber of Commerce, Rochester, N. Y. . . *Joint Meeting A. S. M.*

Saginaw Valley . . Feb. 11 . . *Annual Ladies Night Dinner Dance.*

St. Louis District . . Feb. 9 . . Edmonds Restaurant, St. Louis . . H. P. Stephenson, Pittsburgh Metals Purifying Co., Inc., *"Exothermics For All Metals."*

Southern California . . Feb. 10 . . Rodger Young Auditorium, Los Angeles . . J. Marden, Eutectic Welding Alloy Corp., *"New Welding Procedures."*

Tennessee . . *See Southeastern Regional Conference.*

Texas . . Feb. 10 . . Texas A & M Memorial Student Center, College Station, Texas . . W. C. Jeffery, Mc Wane Cast Iron Pipe Co., *"Career Opportunities in the Cast Metals Industry.*

Timberline . . Feb. 15 . . Oxford Hotel, Denver, Colo. . . D. L. Colwell, Apex Smelting Co., *"Melting, Casting & Properties of Aluminum."*

Toledo . . Feb. 1 . . Heatherdowns Country Club, Toledo, Ohio . . G. L. Miklos, *"Quality Control."*

Tri-State . . Feb. 10 . . Ramada Inn, Tulsa, Okla. . . J. R. Speer, Texas Foundries, Inc., *"Quality Control In The Foundry."*

Twin City . . Feb. 14 . . Jax Cafe, Minneapolis . . T. E. Barlow, International Minerals & Chemical Corp., *"Cupola Practice."*

Utah . . Feb. 14 . . *Valentine Party.*

Western New York . . Feb. 3 . . Sheraton Hotel, Buffalo, N. Y. . . T. E. Barlow, International Minerals & Chemical Co., *"How To Louse Up A Cupola."*

Wisconsin . . *See Wisconsin Regional Conference.*

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Circle No. 121, Pages 141-142

Foundry Trade News

American Seating Co. . . . Grand Rapids, Mich., has been awarded the 50,000 seating contract for the Los Angeles Dodgers baseball club's new stadium in Chavez Ravine. Standards for the seats will be made of gray iron.

Swedish Crucible Steel Co. . . . Detroit, has been authorized use of the Parlanti process for production of steel castings.

Metal & Thermit Corp. . . . has opened a new high-temperature laboratory at Rahway, N. J. It will be used for inorganic chemical, ceramic, metal, and mineral research, and is designed primarily for problems starting at 350 degrees and up.

Gray Iron Founder's Society . . . has received a 1960 safety award from the National Safety Council for its 1959-60 accident prevention program featuring the preparation of safety booklets, a safety leadership publicity program, and organization of safety activity in local management executive groups.

Ductile Iron Society . . . at its meeting in Columbus, Ohio, heard Sam F. Carter, American Cast Iron Pipe Co., Birmingham, Ala., warn that strict controls were absolutely essential in ductile iron production. "Men of technical capacity are required for all work," stated Carter. R. J. Gairing, Wadsworth Foundry Co., stressed the importance of producing samples for preliminary test and examination, even before job shop production of a few castings.

Service and quality are basic elements of a sales program, observed Robert S. Thompson, H. P. Deuscher Co., and Ductile Iron Society president. "Sell your customer your firm, then he will stay sold if your firm serves him effectively," said Thompson.

Members from Indiana, Ohio, Michigan, Alabama, and Canada, participated in a round table discussion of new developments in the production and use of ductile iron castings.

Kaiser Refractories & Chemicals Div. . . . Kaiser Aluminum & Chemical Corp., will build a half-million dollar facility at Columbiana, Ohio, for manufacturing special refractories required in basic oxygen steelmaking. It will be built adjacent to the basic refractories plant.

Brass and Bronze Ingot Institute . . . reports that brass and bronze tonnage this year is holding its own against last year's sales. Institute President Norman Lavin credits the industry's research and education programs with stimulating sales.

Nationalwide Leasing Co. . . . Chicago, has announced a research and development plan for metal companies engaged in government work. Leasing is available on terms of three to five years and ranging from $25,000 to $1 million or more. Types of equipment available include environmental test equipment, electronic gear, business machines and office equipment, machine tools, general production equipment, laboratory equipment, and processing equipment.

American Society for Testing Materials . . . has named Thomas A. Marshall, Jr., as executive secretary. Fred F. Van Atta, formerly assistant secretary, is now treasurer.

Denver Fire Clay Co. . . . has been purchased by Thermal Ceramics Industries, Inc. Denver Fire Clay president, Richard Shepard will continue to serve as president and chairman of the board. Gerald W. Jensen has been appointed executive vice-president and treasurer and will be responsible for the firm's entire operations including the New York and Salt Lake City offices.

Barker Foundry Supply Co. . . . Los Angeles, has been appointed manufacturers representative for WaiMet Alloys Co., Dearborn, Mich.

Bohn Aluminum & Brass Corp. . . . Detroit, has announced that expansion is under way at three plants in Illinois, Indiana and Michigan. The major expansion will increase by 20 per cent the area of the Danville. Ill., plant, which makes heat transfer equipment for heating, air conditioning and commercial refrigeration industries. At Butler, Ind., production facilities for permanent mold castings are being enlarged, while a new engineering building will be added at the South Haven, Mich. plant.

Harry Blumenthal Co. . . . Minneapolis, has recently been formed to act as sales agent and buyer in non-ferrous metals and alloys in the upper Midwest. Aluminum, brass, bronze and zinc base alloys for foundries and die casters comprise the principal line of the firm.

Asbury Graphite Mills, Inc. . . . Asbury, Warren County, N. J., has acquired all outstanding stock of Cummings-Moore Graphite Co. of Detroit, grinders and refiners of Mexican and other graphites, and all of the outstanding stock of their subsidiary Grafitera de Sonora, S. A. de C. V., Guaymas, Sonora, Mexico, miners of natural amorphous graphite.

Precision Metalsmiths, Inc. . . . Cleveland, announces it will acquire Intricast, Inc., Loudonville, Ohio. The acquisition will operate as Precision Metalsmiths, Inc., Intricast Div., producing investment castings for commercial applications. Precision has expanded its resources to provide ferrous and non-ferrous investment castings fo. commercial and military applications.

International Nickel Co. of Canada, Ltd. . . . Toronto, will proceed with the expansion of its iron ore recovery plant at Copper Cliff, Ontario, tripling its capacity. By utilizing a process developed by the firm's research staff the expanded plant will treat 1,200,000 short tons per year of nickeliferous pyrrhotite high in iron content.

Bucyrus-Erie Co. . . . reports that operations at its steel foundry in Erie, Pa., are to be consolidated with the steel foundry in South Milwaukee. The move will bring the work force at Erie down to about one thousand. Some supervisory staff members and key production personnel will be shifted to South Milwaukee.

Chicago Foundrymen's Association . . . announces that John K. Hodgson, secretary, Hodgson Foundry Co., Chicago,

Fred J. Schweizer, front row center, receives gold wrist watch for 40 years service with Advance Foundry Co., Dayton, Ohio. Schweizer, who retired started as a molder in 1920. Advance officers are, back row Wilbur Kramer and Vic Engle; front row, George Kramer and Bill Schneble.

was re-electel president. B. J. Chelini, general manager, Troy Brass & Aluminum Foundry, Inc., was elected vice president, and Harry J. Leddy, general manager, Joliet Foundry, Div. of Infilco, Inc., was re-elected secretary- treasurer. New directors named to the board include: H. H. Horton, partner, Chicago Aluminum Castings Co., R. M. Northrop, president, Ferguson & Lange Foundries, Inc.; and C. A. Larson, partner, Reliance Pattern Works.

Foundry Educational Foundation . . . has established scholarship programs at Wentworth Institute in Boston, Erie County Technical Institute in Buffalo, N. Y., and Western Michigan University, Kalamazoo, Mich. Scholarship funds were provided to F.E.F. by American Brake Shoe Co., Dow Chemical Co., and Griffin Wheel Co.

Magnaflux Corp. . . . wholly owned subsidiary of General Mills, has acquired Metal Control Laboratories, Los Angeles, manufacturer of metallurgical, chemical, and mechanical testing units.

Hardinge Mfg. Co. . . . York, Pa., has completed a $300,000 foundry modernization and expansion program started in January, 1960. Improvements include an additional new wing, motive sand slinger, enlarged cupola charging floor, new core ovens, sand muller, and automatic sand handling and sand storage system.

Union Chain Co. . . . Sandusky, Ohio, is a new division of Hewitt-Robins, Stamford, Conn.

Apex Smelting Co. . . . Chicago, has completed a 27,000 square foot addition to its Chicago plant for scrap handling and processing equipment.

C & S Products Co. . . . an affiliate of Barber-Green Co., Aurora, Ill., has added 3200 square feet to the Detroit plant and offices for expanded engineering and accounting departments.

Frederic B. Stevens, Inc. . . . Detroit, Mich., has moved its New England plant from New Haven to Wallingford, Conn.

Chattanooga Pattern & Foundry Co. . . . formerly Chattanooga Pattern Works, has moved to a new address, 1808 Dayton Blvd. The new location includes expanded foundry facilities.

ESCO Corp. . . . is the new name for the 47-year old Portland, Ore., firm formerly known as Electric Steel Foundry Co. The name was adopted to reflect expansion into field. District offices and warehouses are located in principal cities of the United States, including Honolulu, Hawaii. A manufacturing plant is located at Danville, Ill. ESCO-Ltd., has a foundry at Port Coquitlam, British Columbia, and offices, warehouses and manufacturing plants are at Toronto, Ontario, Vancouver, British Columbia, and Montreal, Quebec.

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WHEELABRATOR

STEEL ABRASIVES

Circle No. 122, Pages 141-142

Let's Get Personal . . .

Edward Feisinger . . . has been named labor relations manager of Crouse-Hinds Co., Syracuse, N. Y. **John Feola** becomes general foreman, iron foundry. **Anthony Izzo** has been promoted to general foreman of the non-ferrous foundry. **Gunther J. Landers** is now product development manager.

Orville C. Christensen . . . is now in charge of sales of heat and corrosion resistant alloy castings, Minneapolis Electric Steel Castings Co.

K. A. Miericke . . . is general manager, Racine Foundry & Mfg. Co., Detroit.

A. J. Fruchtl . . . James B. Clow & Sons, Inc., is now technical director of Metters-Clow Pty., Ltd., Melbourne, Australia.

A. J. Fruchtl

C. F. Joseph

Carl F. Joseph . . . technical director, Central Foundry Div., General Motors Corp., has retired after 43 years of service. He had been technical director of Central Foundry Div. since 1946 and served its forerunner, Saginaw Malleable Iron Div. as chief metallurgist from 1922 to 1946. He was responsible for many technical improvements, especially well known for the development of ArmaSteel, pearlitic malleable iron.

In 1943 he received the AFS William H. McFadden Gold Medal for his contributions to the foundry industry and in 1959 received the Charles H. McCrea Medal of the Malleable Founders' Society. He has written three AFS international exchange papers.

Clayton F. Devine . . . elected to newly created position of executive vice-president and member of board of directors, Ottawa Silica Co., Ottawa, Ill.

Walter J. Nock . . . is now vice-president, Mexican Div., American Smelting & Refining Co.

James J. Keeley Jr. . . . now eastern area sales engineer, Precision Castings Co., Div. Precasco Corp., Cleveland.

William H. Wilkins . . . now salesman, George Sall Metals, Inc., covering Maryland, Delaware, Virginia, North Carolina and South Carolina, greater Delaware Valley, and eastern Pennsylvania.

George E. Johnson Jr. . . . appointed laboratory manager, Curwensville, Pa., Research, North American Refractories Co.

John E. Krickl . . . is western district sales manager, Lindberg Engineering Co., Chicago, with headquarters at Downey, Calif.

Lloyd H. Strausz . . . named Detroit district manager, Sipi Metals Corp., Chicago **R. S. Wahl** is new Cincinnati district manager.

Peter A. Zampino . . . is manager, metallurgical services, Pennrold Div., Brush Beryllium Co., Shoemakersville, Pa.

Richard F. Kidwell . . . is now regional manager, central New York region, Crouse-Hinds Co., Syracuse, N. Y

Donald Fosnaugh . . . appointed controller, Superior Foundry Inc., Cleveland.

Julius J. Harwood . . . named manager, metallurgy department, Ford Motor Co. scientific laboratory, Dearborn, Mich.

Jack Morgan . . . has been appointed technical service manager of Foundry Services, Inc., Cleveland. Formerly chief metallurgist for Foundry Services (Canada) Ltd., Morgan had also been affiliated with High Duty Alloys, Ltd., Stough, England.

J. Morgan

T. Giszczak

Thaddeus Giszczak . . . is promoted to divisional chief metallurgist at Central Foundry Div., General Motors Corp., Saginaw, Mich. He is past chairman of the Toledo chapter, AFS.

Richard N. Ames . . . has been appointed technical services specialist, Kaiser Refractories & Chemicals Div., with headquarters in Chicago.

John Walker . . . was named general manager of Homer Foundry Corp., Coldwater, Mich. Walker was formerly plant manager of Detroit Gray Iron and Steel Foundries, Inc. **Robert Button** was appointed assistant general manager.

W. W. Edens . . . has been appointed assistant director of the research division, Allis-Chalmers Mfg. Co., Milwaukee. Edens is past chairman of the Milwaukee chapter, A.S.M. and a past president of the Wisconsin chapter, AFS.

W. W. Edens

S. Ramamurthy

Dr. S. Ramamurthy . . . formerly with the Indian Institute of Science is now superintendent, foundry and forge, Hindustan Aircraft Ltd., Bangalore, India.

Peter E. Berry . . . is now director of sales, Thiem Products, Inc., Milwaukee.

J. Walter Wallace . . . has been named general sales manager of National Bearing Div., American Brake Shoe Co., New York. He will be based at division headquarters at Meadville, Pa.

Alfred S. Harries . . . is refractories sales representative for the Pittsburgh sales office of Babcock & Wilcox Co.

David Spinner . . . has joined the C&S Products Co., Inc., Detroit, as chief engineer. Firm is affiliated with Barber-Greene Co., Aurora, Ill. **George E. Miller** has joined the firm as manager, field sales and marketing.

C. Richard Guilford . . . named manager of Detroit Plastercast Foundry Co., Div. of Racine Foundry & Mfg. Co., Detroit. He has been with the firm for two years in managerial positions.

Francis J. Shank . . . is sales consultant for Swayne, Robinson & Co., Richmond, Ind.

William H. Holtz . . . has retired from American Brake Shoe plant in Baltimore. Employed by the firm for the past 40 years, Holtz had been superintendent for 25 years. He helped organize the Chesapeake chapter of AFS, and has served as chairman.

Leonard J. Novak . . . is sales representative in western Indiana and eastern Illinois for Ohio Ferro-Alloys Corp.

Robert M. Palmer . . . is field sales manager for the industrial and laboratory furnace and oven divisions, Hevi-Duty Electric Co. Div., Basic Products Corp. Other changes: **John C. Lavey**, district manager, eastern sales office,

Little Ferry, N. J.; **E. H. Andrus,** field service manager; **Norman McDonald,** sales specialist for automatic heat treat furnaces.

H. Brown Reinhardt . . . named eastern sales manager for the American Manganese Steel Div., American Brake Shoe Co., New York, N. Y. He succeeds **E. J. Nist,** who has reached retirement age, but who will continue to represent Amsco in the Southeast.

Peter V. Struby . . . is manager, public relations and advertising, Cerro de Pasco Corp., New York, N. Y. Succeeding Struby as manager of the products development division is **James F. Collins.**

Thomas A. Marshall, Jr. . . . has been elected executive secretary of A.S.T.M. Marshall is currently senior assistant secretary of the American Society of Mechanical Engineers.

Victor Stampone . . . is now service engineer with Wheelabrator Co., was formerly with Dodge Steel Co., Philadelphia.

Lloyd Clifford . . . was recently appointed production manager of Olney Foundry Div., Link-Belt Co., Philadelphia, replacing **Wayne Watson,** who has joined U. S. Gypsum Co., Lansdale, Pa.

Robert W. Lindsay . . . has been named head of the department of metallurgy of The Pennsylvania State University. He succeeds **Amos J. Shaler,** who has resigned from the Penn State faculty. Other appointments at Penn State include **Earle R. Ryba** and **John H. Hoke** both named assistant professors in the department of metallurgy.

George D. Haley . . . named supervisor in charge of hard-surfacing rod production for WaiMet Alloys Co., Dearborn, Mich.

Joseph Banach . . . formerly foundry superintendent, Oliver Corp., Charles City, Iowa, joined Auto Specialties, St. Joseph, Mich., as assistant foundry superintendent.

Glenn G. Tenney . . . has been named manager of the Philadelphia office, National Malleable & Steel Castings Co., succeeding **Russell J. Wittmer.**

Nathan M. Miksch . . . has been elected president of Newark Die Co., Inc. He was formerly treasurer of the firm. Also announced is the appointment of **Victor P. Bergquist** as plant manager.

William A. Wissler . . . retired senior metallurgist of Union Carbide Metals Co., Div. of Unon Carbide Corp., received the Frank J. Tone medal award recently. The medal is awarded to the person who has made outstanding contributions to the science of metallurgy by the Niagara Frontier section of American Institute of Mining Metallurgical and Petroleum Engineers.

obituaries

Norman J. Barnett, foundry superintendent, M. Greenberg's Sons, San Francisco, Calif.

John A. Burke, 66, owner of the former Wisconsin Grey Iron Foundry Co., Milwaukee. He operated the company from 1922 until 1959 when he liquidated the business.

Horace Witherington, president of H. V. Witherington Co., foundry and pattern-making firm, Philadelphia. He was also owner of the Oxford Pattern Works of Philadelphia.

Bruce Koepp, 68, traffic manager 46 years for Davenport Machine & Foundry Co., Davenport Iowa.

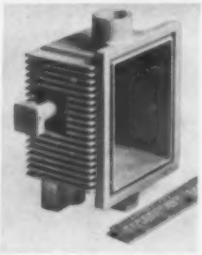
A. Lysle Dyer, plant manager, Buckeye Foundry Co., Cincinnati. He was president of the Miami Valley Foundrymen's Association and had been active in the National Foundry Association and Gray Iron Founders' Society.

SCIENTIFIC
PRESSURE CAST
MATCHPLATES
CHECKED FOR QUALITY
7 WAYS
Inspected at 7 points of manufacture for highest possible matchplate quality . . . Scientific is the only producer using patented new Fortechneider Shift Indicator.

THE SCIENTIFIC CAST PRODUCTS CORP.
1390 East 40th Street • Cleveland 3, Ohio

Circle No. 123, Pages 141-142

Precise Investment Casting
for
High Production!
Fine Finish!
Low Reject Rate!



Saunders Investment Casting Materials help you make Precise Investment Castings. Intricate parts with cores, under-cut sections, etc., can be cast in one piece at one time! Production can be increased, tolerances held closely with fine surface finish.

Sherwood Wax Injection Presses work at lower temperatures to give precise pattern production — Saunders "Blue Wax" has high tensile strength, hard surface and low ash content to give castings a better surface finish and reliable adherence to tolerance. High Quality Refractory Materials offered for shell or monolithic molds. Complete plant set-up for precision investment casting available including Ovens, Fluidized Beds, Turntable Mixers and melting equipment.

Write for Information today,
— latest bulletins or complete catalog.

Alexander Saunders & CO., INC.
95 Bedford Street, New York 14, N. Y.

Circle No. 124, Pages 141-142

For The Asking

Build an idea file for improvement and profit.
Circle numbers on literature request card, page 141, for manufacturers' publications.

Industrial hand trucks . . . two-wheel type, are available in capacities of 400 to 1000 lb. Truck frames are tubular welded steel with heavy axles and solid rubber or pneumatic tired wheels. Four-page bulletin illustrates standard and special types and specifications. Harper Trucks, Inc.

Circle No. 49, Pages 141-142

Specifying magnesium finishes . . . reprint discusses availability and relative merits for chemical treatments and paints. Explains cleaning methods, chemical treatments comparison of organic vehicles for coating, estimated finishing costs, and commercial finish systems. Dow Metal Products Co., Div. Dow Chemical Corp.

Circle No. 50, Pages 141-142

Industrial furnace equipment . . . for heat processing, includes chart for selecting right unit of 24 models. Units include gas, electric, and oil-fired types. Sunbeam Equipment Corp.

Circle No. 51, Pages 141-142

Safety course . . . is a study-by-mail program for industrial foremen. Solves the problem of keeping these key men on the job while they learn the necessary safety know-how. National Safety Council.

Circle No. 52, Pages 141-142

Alloy steel casting . . . advantage and engineering properties plus welding and machining data on "T-1" are contined in four-page bulletin. Reportedly has excellent surface finish and may be cast in thinner sections than practical with other commercial low alloy steels. Alloy Steel & Metals Co.

Circle No. 53, Pages 141-142

Centrifugal blast cleaner . . . Bulletin depicts how firm's patented Rotoblast impeller uses controlled centrifugal force for its blast cleaning power. Revised booklet contains diagrams and cut-away drawings showing how the latest design refinements enable unit to produce quality cleaned surfaces. Pangborn Corp.

Circle No. 54, Pages 141-142

Overhead materials handling . . . is explained in new issue of "Engineering and Application Data" booklet. Various types of carriers, cranes, tractors, track switches, grabs and electrification are described. Detailed

NEW! Stahl Self-Pouring AUTOCAST

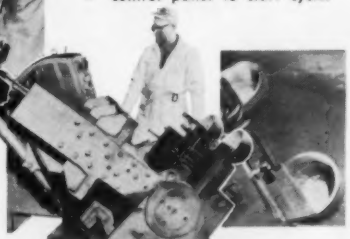
With Standard Dual Power Unit, the Permanent Mold Casting Machine That:

- Pours "two-up" with one man.
- Eliminates turbulence with simple gating.
- Pours exactly alike at a given setting.
- Adjusts for any rate of pour.
- Prevents flash at bottom of mold.
- Assures progressive solidification.

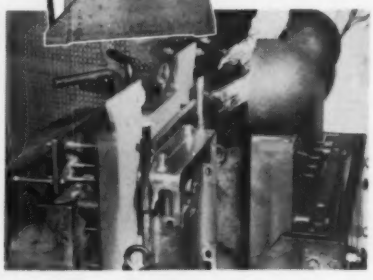
Write for literature describing other standardized permanent mold operating equipment.

1 Operator pushes button on control panel to start cycle.

2 Operator pours into holding basins.



3 Machine moves automatically to vertical position, pouring metal evenly down a gentle incline.



4 After preset cooling interval, machine opens and ejects casting, automatically.

STAHL SPECIALTY COMPANY
KINGSVILLE, MISSOURI
Better Castings from Better Equipment

Circle No. 125, Pages 141-142

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Silvery Pig Iron	20
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Shell Core Machines	9
Temperature Measuring Equipment	148

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Are you looking for information on any of the subjects listed in the left hand column? Our MODERN CASTINGS advertisers have carefully prepared important material on each of these topics to help advance your metalcasting practices. You will find it on the page shown opposite the subject of your interest.

Technical literature is also available on these and many other subjects. Just circle the correct number on the card below that corresponds to the Circle No. shown with each ad and new products items in "New Products and Processes" and "For the Asking" departments.

Here's your opportunity to build a valuable reference file of new products, processes, and techniques.

JANUARY 1961—1

Valid through March 1961

NEW EQUIPMENT AND MATERIALS

1	13	25	37	49	61	73	85	97	109
2	14	26	38	50	62	74	86	98	110
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Golf and Wolf Rds.

Des Plaines, Ill.

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Here's your opportunity to build a valuable reference file of new products, processes, and techniques.

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JANUARY 1961—2 — Valid through March 1961

NEW EQUIPMENT AND MATERIALS										ADVERTISED PRODUCTS							
1	13	25	37	49	61	73	85	97	109	121	133	145	157	169	181	193	205
2	14	26	38	50	62	74	86	98	110	122	134	146	158	170	182	194	206
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12	24	36	48	60	72	84	96	108	120	132	144	156	168	180	192	204	216

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Position

Company

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Pig Iron	4, 24, 25, 30
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Sand Binder, Sodium Silicate	135
Sand Conditioning Equipment	29, 120
Silvery Pig Iron	20
Spectrographic Standards	143
Shell Core Machines	9
Temperature Measuring Equipment	148

studies of track design, peening and stresses are given. Cleveland Tramrail Div., The Cleveland Crane & Engineering Co.

Circle No. 55, Pages 141-142

Measuring presence of calcium . . . A new 2-page data sheet describes continuous, automatic method for determining the presence of calcium down to parts per million at a rate of 20 analyses per hour. Flow diagram of the analytical system, and actual chart recordings derived, are included. Technicon Controls, Inc.

Circle No. 56, Pages 141-142

Air grinders . . . Illustrated folder giving technical details on firm's complete line of air grinders, plus a description of new safety valves on the manufacturer's 6-and 8-inch units is available. Thor Power Tool Co.

Circle No. 57, Pages 141-142

Cutters, surfacers, grinders . . . and other metallurgical equipment are depicted in 6-page brochure. Featured is the 1303 AB Simplimet Press, in which either bakelite or transoptic materials may be compression molded. In addition, AB Premolds can be used with this unit. Buehler Ltd.

Circle No. 58, Pages 141-142

Resins for missiles . . . Bulletin features use of epoxy resins in the production of missiles prototypes and missile components. Also data are presented relating to the product's use at high temperature. Too, the effect of adding small amounts of aluminum powder on epoxy castings is discussed. Furane Plastics, Inc.

Circle No. 59, Pages 141-142

Inspection lights . . . highlighted in the bulletin. Twelve types are described and illustrated, including direct types for surface or interior inspection; prefocused; adjustable focus; combined with magnifying lenses; with rotatable mirrors; and borescopes for right angle vision in small bores. Welch Allyn, Inc.

Circle No. 60, Pages 141-142

Gating zinc die castings . . . Booklet descirbes techniques for various shapes, sizes and dimensions. Also featured in 48-page work are multiple cavity arrangements; runner and sprue details; overflow well details, and gating and die temperature. Also, methods to avoid soldering the die are detailed. American Smelting and Refining Co.

Circle No. 61, Pages 141-142

Trackmobile . . . vehicle which can run on rail or road, is described in a cartoon booklet called, "Tricky the Trackmobile." Unit's versatility in switching, spotting, hauling and other functions is stressed. Whiting Corp.

Circle No. 62, Pages 141-142

Shell Molding . . . Story of a firm which recently adopted shell core process is depicted in 6-page booklet. Results of the change is explained by officials of the company. Also featured are field reports on other users of shell cores. Durez Plastics Div., Hooker Chemical Co.

Circle No. 63, Pages 141-142

X-Ray protective materials . . . New 36-page booklet contains details and specifications to serve basic needs for preparation of installation of X-Ray shielding and other radiological protection. X-Ray Protective Div., Ameray Corp.

Circle No. 64, Pages 141-142

Plastic Lenses . . . optically ground and polished solid plastic lenses are described in 4-page bulletin, including applications, specifications and manufacturing facilities. Fostoria Corp.

Circle No. 65, Pages 141-142

Crane weight indicator . . . Specifications and information describing indicator for all types of cranes, including gantry, bridge, derrick, barge, truck and locomotive units. Martin-Decker Corp.

Circle No. 66, Pages 141-142

Portable belt conveyors . . . Bulletin discusses applications of these portable units. Three types, light weight aluminum, general duty and heavy duty are illustrated. A list of distributors also appears in Bulletin 300. The Rapids-Standard Co., Inc.

Circle No. 67, Pages 141-142

Laboratory instruments . . . including spectrophotometers, pH meters, electrobalances, recorders and related equipment, are highlighted in 16-page brochure. Several pages are devoted to Coleman Metrion pH meters; Junior spectrophotometers, Nitrogen analyzers and Autofillers. Arthur S. LaPine & Co.

Circle No. 68, Pages 141-142

Rubberized abrasives . . . A 22-page manual depicts uses and applications for resilient rubberbonded abrasive wheels, points and sticks for microdeburring, smoothing and polishing. Actual case histories on a variety of typical applications are shown. In addition, the manual outlines the most efficient methods for mounting, dressing and trueing. Cratex Manufacturing Co.

Circle No. 69, Pages 141-142

Underground mining machines . . . A short outline of the development of these crawler-mounted air or A. C. electric powered units, used in mining, shaft-mucking and loading, is included in this 14-page booklet. Adaptability of the various units is illustrated. The Eimco Corp.

Circle No. 70, Pages 141-142

Infra-Red burner . . . Performance curves, data on application, selection and specification of units are discussed in this 4-page data sheet. Gas-fired, Infra-Red burner is designed for low-temperature industrial processing applications, such as curing shell molds, foundry cores, and drying metal. Bryant Industrial Products Corp.

Circle No. 71, Pages 141-142

Metal powders . . . Brochure illustrates newly perfected metal powders produced by atomization. Designed for uses in a variety of industrial and experimental applications, powders include stainless steel, spherical and irregular; commercially pure iron; silver; and copper. Federal-Mogul Div., Federal-Mogul-Bower Bearings, Inc.

Circle No. 72, Pages 141-142

STAINLESS STEEL SPECTROGRAPHIC STANDARDS

300 Series (including C, P, S)

All Standards have approximately the same percentage of Iron to make integration of internals constant in direct readers. These Standards are also suitable for X-Ray Fluorescent Spectrographs, 1⅛" round by ⅞" thick.

Series of 3 chill cast samples **$75.00 per set**

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Phone: Adams 3-3243

Circle No. 152, Pages 141-142

Future Meetings and Exhibits

1961

Jan. 18 . . American Institute of Mining, Metallurgical and Petroleum Engineers Third Mechanical Working Committee Conference, Penn-Sheraton Hotel, Pittsburgh, Pa.

Jan. 23-26 . . Plant Maintenance & Engineering Show, International Amphitheatre, Chicago.

Feb. 9-10 . . AFS Wisconsin Regional Foundry Conference. Schroeder Hotel, Milwaukee.

Feb. 14-17 . . National Metallurgical Laboratory, Symposium "Light Metal Industry in India," Auditorium, National Metallurgical Laboratory, Jamshedpur, India.

Feb. 16-17 . . AFS Southeastern Regional Foundry Conference. Read House, Chattanooga, Tenn.

Feb. 22-24 . . Material Handling Institute, Pacific Coast Show. Cow Palace, San Francisco.

Feb. 26-March 2 . . American Institute of Mining, Metallurgical & Petroleum Engineers, Annual Meeting. Ambassador and Chase-Park Plaza Hotels, St. Louis.

March 1-2 . . Malleable Founders Society, Technical & Operating Conference. Pick Carter Hotel, Cleveland.

March 5-9 . . American Society of Mechanical Engineers, Gas Turbine Conference & Exhibit, Shoreham Hotel, Washington, D. C.

March 11-14 . . Steel Founders' Society of America, Annual Meeting. Drake Hotel, Chicago.

March 20-24 . . American Society for Metals, Western Metal Exposition & Congress, Pan-Pacific Auditorium, Los Angeles.

March 21-30 . . American Chemical Society, Spring Meeting. St. Louis.

April 10-12 . . American Institute of Mining, Metallurgical & Petroleum Engineers, Open Hearth Steel Conference. Sheraton Hotel, Philadelphia.

April 12-14 . . American Institute of Mining, Metallurgical and Petroleum Engineers, International Symposium of Agglomeration, Sheraton Hotel, Philadelphia, Pa.

April 18-20 . . Foundry Educational Foundation, Annual College-Industry Conference. Statler-Hilton Hotel, Cleveland.

April 18-20 . . American Welding Society, Annual Meeting and Welding Show. Commodore Hotel and Coliseum, New York.

May 8-12 . . AFS 65th Castings Congress & Exposition. Brooks Hall, Civic Auditorium, San Francisco.

May 9-11 . . Material Handling Institute, Eastern States Show. Convention Hall, Philadelphia.

May 10-12 . . National Industrial Sand Association, Annual Meeting. The Homestead, Hot Springs, Va.

May 22-26 . . American Society of Tool and Manufacturing Engineers. Engineering Conference and Exhibit, New York City.

June 8-9 . . Malleable Founders Society, Annual Meeting. The Broadmoor, Colorado Springs, Colo.

June 15-16 . . AFS Chapter Officers Conference. LaSalle Hotel, Chicago.

June 18-20 . . Alloy Casting Institute, Annual Meeting, Hot Springs, Va.

June 22-24 . . AFS Penn State Regional Foundry Conference. Penn State University, University Park, Pa.

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sells more
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than anyone else
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below for a free test sample.

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Detroit 16, Michigan

Please rush me a free test sample of Stevens Liquid Parting!

NAME _____ TITLE _____
COMPANY _____
ADDRESS _____
CITY _____ ZONE _____ STATE _____

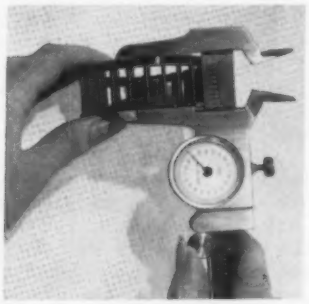
Circle No. 153, Pages 141-142

New Products and Processes

What's new in foundry methods and equipment? Summaries of many are presented below. Circle corresponding number on free postcard, page 141. Mail it to us; we'll do the rest!

Dial Vernier Calipers Provide Rapid Measuring for Die Casters

Dial vernier caliper offers rapid precision measurement with accuracy to 0.001 inch. Circular dial vernier scale permits direct measurement of both inside and outside dimensions. Caliper is equipped with two sets of double jaws plus a depth gage rod. Internal measurements as small as 0.040 inch can be made accurately. Four sizes are available. Tital Tool Supply.



Circle No. 1, Pages 141-142

Ultrasonic Testing Equipment Checks for Aircraft Quality

Ultrasonic inspection of hardened steel detects minute, below-surface flaws. A cathode-ray tube depicts presence of gas bubbles and slag particles. High frequency sound waves, projected into the steel detect shrinkage, internal flakes, cracks, concentrations of inclusions, segregations and laminations, as well as particle and bubble defects.

Material, submerged in a tank of water to increase sensitivity, is bombarded by ultrasonic waves. Defects act as an obstacle to sound beam and information is transmitted to the cathode ray tube via an electrical cable connected to the quartz crystal sound generator.

Interpretation of CR tube is based on predetermined standards achieved by studying blocks of metal with varying amounts of intential defect. Equipment can show extent of defect and its location in the metal. Allegheny Ludlum Steel Corp.

Circle No. 2, Pages 141-142

Blast Cleaning Abrasive Ranks Between Steels and Malleables

Blast cleaning abrasive ranking between present malleables and steel in performance and initial cost lasts 2½ times longer than similar materials. The abrasive is reported to be as close to steel as is possible to make in a cupola.

Both speed of cleaning and longevity of the abrasive, while less than that of steel shot, is reportedly better than most malleable abrasives. Pangborn Co.

Circle No. 3, Pages 141-142

One-Man Loading System for Trucks Makes Use of Skid-Mounted Beds

One-man loading system allows loading and dumping of skid-mounted truck beds including boxes, flatbeds, containers, and special equipment. Skid-mounted beds automatically lock into place to become an integral solid part of the truck. Will handle work loads in excess of 30,000 pounds. Cal-Tex Div., Tyler Pipe & Foundry Co.

Circle No. 4, Pages 141-142

Infra-Red Heating Unit Converts LP Gas Energy Directly

Infrared heat using LP gas energy directly converted on a catalytically active metal screen is said to increase efficiency and lower fuel costs. Units are suitable for many heat transfer applications such as baking, drying, curing, bonding, preheating softening and evaporation.

Screen itself is radiant heat source and surface temperature can be held automatically at any point between 800 F. and 1500 F by proportionate control of gas flow. Low temperature range permits work to be placed close to heat source shortening heating times and reducing size and cost of heating enclosures.

Standard size panels are available designed to provide heat release rates between 2000 and 12,000 Btu per hour per square foot of emission surface, equivalent to a range of 4 to 24 watts per square inch. Catalytic Combustion Corp.

Circle No. 5, Pages 141-142

Semi-Automatic Flaskless Molding Machine Uses Standard Patterns

Semi-automatic flaskless molding machine uses standard 16x22 in. patterns. Flasks are not required since they are integral part of machine.

Other features include remote control of all pressure and draw movements, power-operated head and pattern-carrying frame, and adjustable, slow draw cope and drag. F. E. North America, Ltd.

Circle No. 6, Pages 141-142

Claim Unusual Strength for High Temperature Refractory Compound

Shapes of unprecedented strength, size, and purity are claimed for titanium diboride high temperature refractory compounds due to new production processes. Special process reduces oxides of titanium and boron to very fine, high-purity powder that can be fabricated into various shapes.

Material maintains a flexural strength of 35,000 pounds per square inch over temperature range of 25 through 2000 C. It has a high mod-

ulus of elasticity similar to ceramic materials. Material is inert to molten aluminum, molten zinc, and molten slags, but is not resistant to molten ferrous metals. Suggested for tapping spouts, funnel linings, valves and gates for non-ferrous operations. National Carbon Co., Div. Union Carbide Corp.

Circle No. 7, Pages 141-142

Automatic Briquetting Machine Converts Nine Tons Per Hour

Fully automatic scrap briquetting press converts up to 9 tons of scrap per hour into cylindrical shape. Individual briquettes have a density of 80 per cent, weigh 30 to 40 pounds each and are classified as high grade scrap.

The unit is fully automatic. All moving parts are lubricated by the pressurized operating fluid. Cylinder pressure plates and die holders are cast steel, piston rods are chrome nickel steel, hardened and ground.

Briquettes are suitable for direct charging into furnace or cupola. Machine is capable of handling cast bronze, brass, aluminum, magnesium, titanium and molybdenum. Milwaukee Foundry Equip. Div. SPO, Inc.

Circle No. 8, Pages 141-142

Pulverizer Gives Crushed Sample For Determining Carbon Content

Sample pulverizer uses air powered spinner riveter with mortar and pestle to receive and pulverize sample easily workable for chemical determination of carbon content.

Foundry samples are cooled then inserted in pulverizer which, actuated by a hand lever, pounds and spins the material on each stroke, yielding a finely crushed sample easily analyzed. The unit will also pulverize samples for phosphorus, manganese, nickel and chromium determination. Gardner-Denver Co.

Circle No. 9, Pages 141-142

Exhaust System Removes Welding Smoke, Fume from Closed Area

Exhausting of welding fumes and smoke for closed work areas is made possible by a unit comprised of a special intake nozzle joined to a jet pump casting by a length of flexible tubing. Smoke is exhausted through another connecting section of tubing.

It is powered entirely by compressed air. If required, additional lengths of tubing may be added with no reduction in velocity or volume of smoke removed. Operation requires only connecting unit to an air line positioned to carry the smoke and fumes from work area, with the intake near source. Arcair Co.

Circle No. 10, Pages 141-142

Flow Switch Automatically Corrects Material Stoppage or Sounds Alarm

Flow switch responds to lack of material at critical point in bulk material handling systems and automatically corrects difficulty or sounds an alarm. Flow of material past switch deflects flap and holds it out of operating position. When flow stops, flap swings into operating position and actuates switch which may start an electromagnetic bin vibrator or alarm system. Syntron Co.

Circle No. 11, Pages 141-142

Resin Coated Sand System Promotes Higher Tensile and Hot Strength

Resin coated sand utilizes lubricant for easier removal from pattern. Both a highly flowable round grain sand used for cores and a subangular sand producing high strength shells or cores are being coated.

Standard melt point for resin coated sand is 200-250 F. Sand with different melt points may be ordered where unusual conditions exist. Advantages claimed: uniform coating; higher tensile and hot strength; advancing of melt point to required degree without extensive mixing; no residual solvents trapped in resin. Bennett-Ireland, Inc.

Circle No. 12, Pages 141-142

Tar-Bonded Refractories Possess Long Life, Hydration Resistance

Tar-bonded refractories recently made 30,625 tons of steel in 277 heats with only moderate material loss. Refractories also have high resistance to hydration. Bricks are made four inches in depth with varying widths and lengths. Average brick has density in excess of 180 pounds per cubic foot. Kaiser Refractories & Chemical Div., Kaiser Aluminum & Chemical Corp.

Circle No. 13, Pages 141-142

Semi-Continuous Mold Ovens Offer Thorough, High Speed Drying

High speed mold ovens dry up to 60 molds per day. Push-button control system enables operator to index the cope and drag molds through

Safety Binders . . . . with modern castings

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the oven on a semi-continuous conveyor system. Interlocked indexing system and door controls are air powered. Molds move only when door is open. Heat is provided by individual gas-fired recirculating systems

Molds are dried to about one inch in depth providing benefits of dry sand practice such as better casting finish, fidelity to pattern and lower cleaning costs. Handling costs and fuel consumption are reduced while flask turnover is speeded. Foundry Equipment Co.

Circle No. 14, Pages 141-142

Dry Hearth Furnace for Melting Aluminum Uses Many Fuels

Dry hearth furnace for melting and holding aluminum can be built for operation with gas, oil or combination fuel. Designed for use in permanent mold, sand or die casting plants, the furnace features a sloping hearth that quickly melts aluminum.

Porosity causing moisture evaporates on the hearth before molten aluminum flows into the holding bath. Precise temperature control in the bath reduces scrap loss.

Furnace is easily adaptable to continuous pour operations and may be supplied with side or end dip out wells. Sunbeam Equipment Corp.

Circle No. 15, Pages 141-142

Polyethylene Bags Protect Ingots From Dirt, Dust, and Moisture

Uncontaminated metal ingots receive protection in storage through polyethylene film. One-ton bundles of ingots are stored in large bags from time metal is cooled until shipping. Film controls moisture condensation and prevents dirt and dust contamination. Union Carbide Plastics Co. Div., Union Carbide Corp.

Circle No. 16, Pages 141-142

Special Features on Grinding Wheel Result in More Efficient Cutting

Raised-hub grinding wheel is said to give faster metal removal, longer wheel life, improved safety, lessened operator fatigue, reduced grinder maintenance, and faster mounting and dismounting without tools.

Mounting arrangement consists of redesigned adaptor flange and threaded steel insert molded as an integral part of the wheel with wheel always at a true 90 degrees to the spindle. A. P. deSanno & Son

Circle No. 17, Pages 141-142

New NO-SPILL Bucket

for PAYLOADER® units

A strikerbar-spillguard blade, by hydraulic power, sweeps forward removing excess material. Blade remains forward in transport to retain load.

- . . Eliminates spilling during transport
- . . Saves costly floor and aisle clean-up
- . . Eliminates re-working spilled material
- . . Increases daily productive capacity
- . . Delivers uniform loads for "batching"

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2. Delivers bigger loads as none is lost in transit.
3. Eliminates the dust nuisance caused by light, dry materials spilling in transit.
4. Prevents the accumulation and build-up of spillage along aisles — saves the cost and time of digging up and reprocessing such spillage.
5. Eliminates the contamination and waste involved when different materials are spilled on the same routes.

Three popular PAYLOADER sizes can be supplied with "No-Spill" buckets — the Models HA, H-25 and HAH. Your Hough Distributor will be happy to show you what they can do to improve materials moving efficiency on your operations. See him today.

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Circle No. 154, Pages 141-142

New Books for You . . .

Top Management Handbook . . . H. B. Maynard, Editor-in-Chief. 1248 pages. McGraw-Hill Book Co., Inc., 330 West 42nd St., New York 36. 1960. This is a reference on management and managing fundamentals and proved practices. Sixty industry leaders, from large and small companies and members of management, have set down their ideas and methods. The experienced-based reference tells what management is, not only at the top level, but also in each area of managing activity. Also covered is what managing calls for in the manager's thinking and ability; and how managing can be carried out for the good of the company, manager, and society at large. Book has a foreword by David Rockefeller, vice chairman of Chase-Manhattan Bank. Other thinking represented in the book includes that of William T. Brady, chairman, Corn Products Co., Thomas J. Watson, IBM president; Clarence Francis, Studebaker-Packard chairman; Milton Lightner, chairman of Singer Mfg. Co.; J. Keith Louden, executive vice president, Lebanon Steel Foundry; and many other leaders.

Industrial Electric Furnaces and Appliances, 2nd Edition . . . V. Paschkis and John Persson. 607 pages. Interscience Publishers, Inc., 250 Fifth Ave., New York 1, N. Y. This revised, enlarged edition deals primarily with thermal and electrical problems of electric furnace design. Because of its importance in furnace design and operation, heat transfer is considered in the first part of the book. Heating the charge is covered as well as heat losses. In chapter two arc furnaces are discussed, with open-arc heading off the chapter. In this, basic thermal considerations are covered plus a section on the furnace body. Other topics include: the electrodes, busses, transformer and reactor, furnace control, operating, and several discussions. Submerged-arc furnaces are discussed plus special furnaces. Chapter three is devoted to a discussion of resistance furnaces and appliances; chapter four, with induction and dielectric heating; and in chapter five selection of furnaces is discussed.

Steel Castings Handbook. 680 pages. Steel Founders' Society of America, 606 Terminal Tower, Cleveland 13, Ohio. 1960. New edition has been completely rewritten to make it more useful to users of steel castings, design engineers and materials engineers. It is the most complete revision that has been produced in 20 years. New chapters on purchasing steel castings, machining steel castings, list of definitions of terms relating to production and use have been incorporated. Topics covered in the volume, which is 10 per cent larger than the 1950 edition, include: advantages and applications of steel castings, fundamentals of design, patterns, tolerances, properties and physical values, heat treatment principles, welding, manufacturing, testing, inspection, and quality control.

Ultrasonics and its Industrial Applications. O. I. Babikov. 230 pages. Consultants Bureau Enterprises, Inc., 227 West 17th St., New York 11. 1960. This translation from the Russian covers recent Soviet advances. Discussed are: fully ultrasonic con-

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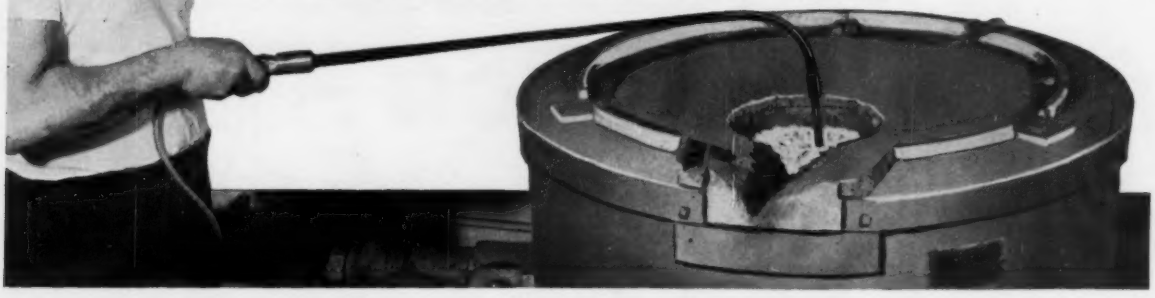

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trol methods, action of high-intensity ultrasonic oscillations on various technological processes, ultra-sonic drilling techniques, and ultrasonic pulse methods of flaw detection and physiochemical research. Fundamental physical principles are presented concisely.

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The Editor's Forum . . .

Help needed . . . for better steel castings. A new alloy developed at the Mellon Institute, Pittsburgh, Pa., shows promise of achieving 350,000 psi ultimate tensile strength, 300,000 psi yield, and 5 per cent elongation. But they need the cooperation of a steel foundry for some experimental melting and casting. Any volunteers? Here's your chance to help advance the frontiers of metalcasting technology. Write if interested.

Scrap Castings can be valuable . . . Don't shed too many tears over a scrapped casting. Instead consider it a research project. Don't hurriedly remelt it as fast as you can to get it out of sight. Consider it an experimental guinea pig for careful dissection. Saw the casting through critical sections and see if you have sound metal. Maybe you'll spot porosity indicating a need for different risering, or dirt may suggest a change in gating. A sectioned riser might reveal that the casting is feeding the riser instead of vice-versa. Cut tensile bars out of choice locations to determine what sort of physical properties you can expect in critical areas. This is the kind of intelligence that impresses customers more than the tensile strength obtained on a separately cast test bar. Take random chemical samples to see if segregation is any problem. Make a hardness survey on cast surfaces. With this scientific approach you will wind up knowing more about your foundry practices from this one scrap casting than you can learn from a hundred good ones. So don't take the negative approach and write-off the bad ones as scrap. Be positive, charge them to research!

There's a lot of talk . . . and a lot of writing . . . about the hypereutectic aluminum-silicon alloys. Grain refining the inherent coarse grain seems to be of foremost interest right now. An article in this issue of MODERN CASTINGS tells how to grain refine with 0.10—0.16 per cent phosphorus. More papers are scheduled for subsequent issues of MODERN CASTINGS. We're interested in hearing from any of you who have succeeded into putting this high silicon alloy into production. Drop us a line if you have.

Andrew Jenckes, J. S. White Co. . . . was telling us about an old New England custom. Seems they mull steel shot into their oil bonded core sand mix to improve its chilling power. Mix can be loaded up with as much as 30 per cent of round shot. Then you can shape the core or mold section to any contour and gain chilling action in selected areas. Sand-shot mix is about 50 per cent as effective as a metal chill. Remember the faster you cool the casting down to the solid state the less volume of metal you need in risers. Jenckes recommends this concoction for ductile iron—densifies the structure and improves the yield. Don't see why it wouldn't be good for non-ferrous metals too. Any of you foundrymen had an experience with it?

Question: How fast is the pace of competition? **Answer:** One of the zinc die castings that received honorable mention in the "Zinc Die Casting of the Year" contest several months ago has already lost the production job to the plastics industry.

New look in military equipment . . . while strolling through a foundry cleaning room the other day I was surprised to see a 500 horse power air cooled aluminum engine. Seems they are being made for airborne military tanks. Weight saving in engines not only helps air delivery but also contributes to maneuverability on the ground. Cast aluminum tracks are also undergoing tests. Now if someone can just come up with an aluminum alloy for armor!

Jack Hinman

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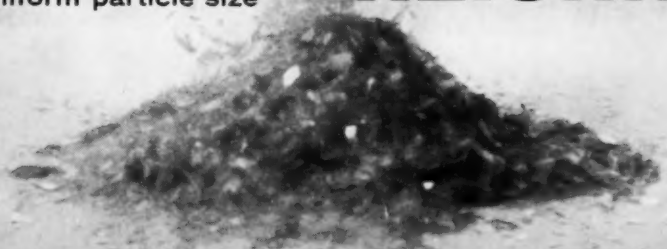

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